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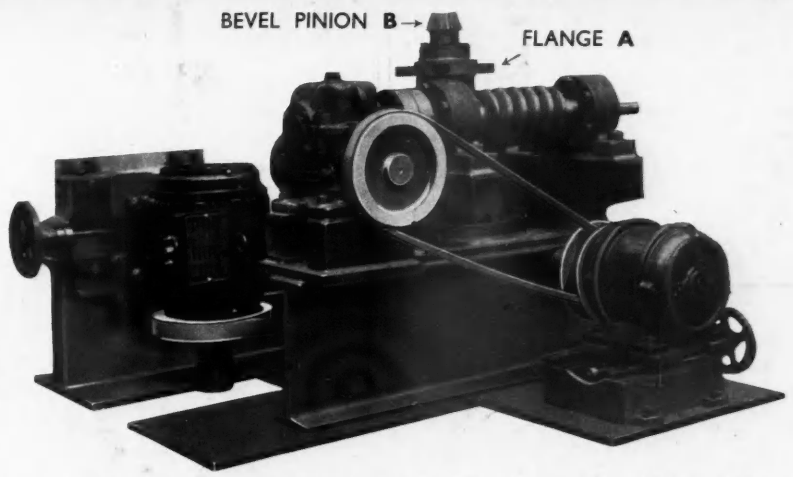

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Earnings in the Engineering Trades

IN the current issue of the *Ministry of Labour Gazette* some unusually interesting tables are given in which the average earnings in specific trades are compared with those of October, 1938. The figures relate to an inquiry which was instituted by the Ministry of Labour and National Service in July last. In the metal, engineering, and shipbuilding industries the average earnings of all workers in the week ended July 20th last were 85s. 1d., which shows an increase of 43·2 per cent. over those for October, 1938. The average earnings of men were 100s. 3d. (increase, 36·3 per cent.); of women, 43s. 11d. (increase, 34·4 per cent.); of youths and boys, 36s. 4d. (44·9 per cent.); and of girls, 25s. 8d. (increase, 32·2 per cent.). In the motor vehicle and aircraft industries the average earnings, which are included in the foregoing figures, were 106s. 5d., and the average earnings of men 114s. 11d. A number of the principal firms engaged in these industries, however, did not include separate particulars of the earnings of men, women, boys, and girls. As the earnings of all workers in these establishments averaged 120s. 7d., compared with 96s. 7d. in the remaining establishments, the average as analysed by age and sex would probably have been considerably higher if the full figures had been available. Other figures are given, showing the average earnings in the textile, clothing, food, drink, tobacco, woodworking, paper, printing, &c., and building and contracting trades. In most of these trades the increases recorded are lower than those of the metal trades. The Ministry states that the increases shown by the inquiry were not wholly due to conditions arising from the war, for between October, 1938, and the beginning of September, 1939, there was a substantial improvement in employment coupled with a slight rise in the average level of rates of wages, as a result of which the average earnings in many industries must have been higher at the outbreak of war than in October, 1938. The average rise in wages during that period is estimated to have been less than 1 per cent.

Enemy and British Air Losses in November

A GENERAL statement which is now available concerning enemy and British air losses during the month of November shows that the German aircraft confirmed as destroyed over Britain and British waters last month included 97 bombers, 103 fighters and fighter-bombers, and 1 flying boat. To these must be added the Italian aircraft confirmed as destroyed over Britain and British waters. They are 7 bombers and 13 fighters, making a total of 221 aircraft. The German aircraft confirmed as destroyed over enemy or enemy-occupied territory and enemy waters during November, 1940, include 1 bomber, three fighters and fighter-bombers, 2 seaplanes, and 2 flying boats, making a total of 8 machines and a total for all quarters of 229 aircraft destroyed. Out of 53 British fighters which were lost during the month, 28 pilots were saved. British aircraft, other than fighters, lost over enemy or enemy-occupied territory or enemy waters during November amounted to 48 machines. In the Mediterranean theatre of war and Abyssinia, Italian East Africa, &c., the number of Italian aircraft which were destroyed during November, 1940, numbered 59, and the number of British aircraft lost in the same area during the month under review was 18. It is noted that these comparative figures include aircraft destroyed by R.A.F. aircraft, and by ground defences of all kinds, but they do not include any enemy aircraft which may have been destroyed by the Greek Air Force, by the armies in the field, by H.M. ships or armed vessels at sea, or in port, or by aircraft of the Fleet Air Arm. The figures were issued just following the close of November and some slight revision may be necessary when the month's figures are finally reviewed.

Welfare in Industry

THE annual meeting of the Industrial Welfare Society took place in London on Wednesday afternoon, December 4th, when the annual report of the Society was submitted to the members. It states that a year of war has seen a remarkable development in industrial welfare and a change in official policy with regard to it. Such a change, the report states, was not wholly unexpected, for war conditions and the need for increased output have meant a considerable strain on the worker, which, unless health and general welfare were safeguarded, was bound to lead to breakdown, with serious consequences, not only to the individual, but to the nation. That was only too well illustrated in the last war. At the outbreak of the present war there was some doubt, the report records, as to the future position of the voluntary industrial welfare movement, since by emergency legislation the Government acquired considerable powers to regulate industry. In the last annual report the then Minister of Labour, it was mentioned, had expressed the view that industrial welfare work should be carried on voluntarily as one of the responsibilities of industry itself. Increasing Government control caused some hesitation as to the ultimate issue, and with the speeding up of production a change of Cabinet brought in a new Minister of Labour and a new policy. Mr. Ernest Bevin made industrial welfare one of the main planks of his platform, but in doing so he recognised the value of the part which existing voluntary organisations were playing in the industrial field. The welfare officers appointed by him are now working closely with voluntary bodies in their areas. At the centre the Industrial Welfare Society, on account of its long experience, is being constantly consulted by the Ministry of Labour and other Government Departments on the many welfare problems which are now appearing in new and acute forms. The Society is working in close co-operation with the Factory and Welfare Department on inside welfare questions. In presenting its annual report, which is the twenty-first, the Council places on record its deep appreciation of the continuing personal interest shown by the Society's Patron, His Majesty the King, in its work.

Westland Aircraft Limited

IN his chairman's address at the fifth ordinary general meeting of Westland Aircraft, Ltd., which was held in London on Thursday, November 28th, Lord Aberconway referred to the continued expansion of the company's activities. Some two years ago, he said, the company's main works were considerably extended. The further expansion of output had been achieved by an extensive and well-organised system of sub-contracting. New capacity for aircraft production had been set up in sub-contractors' premises within existing buildings, and largely by the use of existing equipment. Work had been taken to the men; displacement of labour had been avoided and the company had had the advantage of local housing, local skill, and local management. It had in this connection done everything possible during last year to assist others in changing over from peace-time to war-time products. The company further had established a number of branch factories under its direct supervision. The company's technical department, continued Lord Aberconway, had been very fully occupied on special developments which, it was hoped, would play their full part in our country's bid for supremacy in the air. The company had also undertaken responsibilities in the repair of aircraft, both by performing work itself and by assisting others. In order to facilitate the general organisation of repair work a private non-profit-making company—Westland Repair Organisation, Ltd.—had been formed, which was limited by the guarantee of John Brown and Co., Ltd., and Associated Electrical Industries, Ltd.

A National Industrial Electric Lighting Service

THE fifth report of the Departmental Committee appointed to consider factory lighting, and the legislation governing the lighting of factories, have both formed the subject of Journal notes. At a recent meeting held at the Lighting Service Bureau, eight of the various Associations interested in electric lighting were asked to nominate representatives to an Executive Committee which should deal with any matters referred to them by Government Departments concerning artificial illumination. Following the meeting, the whole matter of war-time factory lighting has now crystallised in the establishment of the National Industrial Electric Lighting Service, with its secretariat vested in the Lighting Service Bureau, London, and with local offices at Glasgow, Newcastle-upon-Tyne, Leeds, Manchester, and Birmingham. The chairman is Sir Duncan Wilson, and the secretary is Mr. W. J. Jones, M.Sc., M.I.E.E. The object of the scheme is to mobilise the services of qualified lighting engineers throughout the country, in order that employers may be advised, with the minimum of delay, of the best and most economical way of complying with the new lighting regulations made by the Minister of Labour and National Service. Knowledge and experience can be brought to bear upon any problem of industrial lighting, and any employer or factory executive who may be doubtful whether his present installation conforms to the requirements of the Government Regulations should take the advice of his usual electrical consultant, or apply to the Service at the address most convenient. A qualified illuminating engineer will be appointed to examine the conditions and draw up a suitable scheme, and no charge will be made. The employer is, of course, at liberty to engage his own electrical contractor for the necessary alterations, or to let the Service suggest one. The centres to which application should be made, when required, are as follows:—National Industrial Electric Lighting Service: E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2; E.L.M.A. Lighting Service Bureau of Scotland, 29, St. Vincent Place, Glasgow; British Electrical Development Association, Inc., Commercial Union Buildings, Pilgrim Street, Newcastle-upon-Tyne; E.L.M.A. Lighting Service Bureau, Circle House, 29, Lady Lane, Leeds, 2; British Electrical Development Association, Inc., 1, Dickinson Street West, Manchester, 2; British Electrical Development Association, Inc., 111, New Street, Birmingham, 2.

Engineers' Wages

THE National Committee of the Amalgamated Engineering Union held a meeting at Southport on Thursday of last week, November 28th, when the deadlock which had taken place in the negotiations with the Engineering and Allied Employers' National Federation with regard to the union's application for an increase in wages was discussed. It was decided to submit the claim for an advance of 3d. an hour and the restoration of the pre-June, 1931, working conditions to the National Arbitration Tribunal. In the course of his speech Mr. J. Tanner, the President of the Union, said that the employers, who had rejected the claim, did not attempt to deny that they were making profits at a high rate; but they said that if an increase of wages were paid the Government would have to foot the bill, since they would pass on the increase either by raising the prices of armament contracts or by paying less in excess profits. The Union's application, he contended, was rejected, not because the industry was not in a position to meet the increased charge, but because the employers said that it would not be in the interests of the country. Was there any suggestion, he asked, that the engineers were trying to exploit the war in their own interests? If so, it was emphatically untrue. They were satisfied that their demand was fair, reasonable, and fully justified. Various amendments were put to the meeting, including one suggesting that negotiations with the employers should be reopened forthwith, on the original demands, and that to enforce them the members should be prepared to withdraw their labour. Another amendment instructed the executive to make an immediate application to the National Arbitration Tribunal to consider the wage claim without prejudice to any further claims of the Union's freedom of action. This amendment was carried by 25 votes to 11, and the proposal for strike action was not put to the conference. The amendment for arbitration was subsequently carried by a large majority.

The Royal Society

ON Saturday last, November 30th, at the annual meeting of the Royal Society, Sir William Bragg, at the close of five years in the presidential chair, gave the anniversary address. In it he referred to the many eminent scientists who had died during the last year. He found, he said, no vestige of sadness in remembrance, for their work had been immediately appreciated. They were pioneers, and the scientists of that time, nearly half a century ago, streamed after them. With regard to the younger generation, Sir William said that he felt that the young men of to-day were maintaining in full force the tradition they had received. A new factor had been introduced, for as they extended the record of the facts of Nature they found themselves compelled at the same time to consider a new problem—the relation of those facts to society and to the government of nations. He expressed his admiration of the willingness, vigour and ability with which the newer generation got to work. Sir William said that a new opportunity had been opened by the appointment of the Scientific Advisory Committee, over which Lord Hankey presided. Its new and significant feature was its close and direct association with the Cabinet, the central body that governed the nation. The new Committee was not part of any executive body, and it was not hampered by traditions or set habits. It had time to consider the whole field of scientific knowledge and its possible influence on practice. With regard to the present position of scientific knowledge, it was not universally, nor even sufficiently understood, he thought, how important natural knowledge had become. Since experimental science had assumed such a commanding influence on all our affairs we ran the risk of great perils if we took no account of it and left its uses to others, perhaps less well disposed than ourselves. It became a first duty to direct our steps accordingly. Sir Henry Dale, the Director of the National Institute of Medical Research at Hampstead, was elected the new President, and Sir Henry Tizard the new Foreign Secretary of the Society. New members of Council include Professor Blackett and Professor J. B. S. Haldane.

High Precision Gauging

No. III

(*Continued from page 341, November 29th*)

THE COOKE MEASURING MICROSCOPE

THE instrument illustrated in Fig. 12 has been produced by Cooke, Troughton and Simms, Ltd., of York, to meet the demand for a simple, robust and portable measuring microscope for use in the workshop, tool and inspection rooms, and the laboratory. The equipment has been designed with the object of making the instrument useful for as wide a range of applications as possible. The employment of this instrument, it is claimed, should enable factories having one of the elaborate tool-makers' microscopes, which are often housed in air-conditioned rooms, to confine the latter to its primary functions, whilst the microscope illustrated may be used for examination work in the factory or elsewhere, as may be most convenient.

The Cooke measuring microscope is designed for the examination of opaque and translucent specimens and profile forms. For the illumination of opaque objects, surface inspection and Brinell impressions, &c., a vertical illuminator has been built into the body tube so that shadow effects which are likely to upset accurate measuring have been eliminated. The vertical illuminator consists of a glass plate reflector, together with a built-in light source, and is fitted with an iris diaphragm for

FIG. 12—MEASURING MICROSCOPE—COOKE, TROUGHTON

the control of light intensity and a second iris for the regulation of the illuminated area of the specimen.

The stand comprises a horseshoe base plate with three machined surfaces arranged equilaterally and two vee surfaces. Thus the microscope and stand can be used either on a table or surface plate, and with the vee surfaces it can be mounted on a cylindrical body. The upper side of the base plate has three studs, which carry the interchangeable stages. The object stage for opaque specimens is provided with circular motion and two spring clips mounted in a machined groove. The stage for transmitted light is of circular design fitted with a glass disc capable of rotation, and spring clips are also provided for clamping the specimen. The pillar accommodating the micrometer traversing mechanism and microscope is telescopic and is provided with a clamp, the weight of the microscope being taken by a spring, so that on unclamping the microscope it will not fall to the base of the pillar. The microscope body tube is fitted with an inclined monocular eyepiece. Focusing is effected by means of a rack and pinion operated by milled heads on each side of the tube.

Three objectives are provided, giving magnifications of 27, 39 and 54. The eyepiece is fitted with a cross line which can be focused independently to suit the observer's eye. The microscope is mounted on a ball-bearing slide, which renders the movement very free and consistent. This movement is controlled by a micrometer screw having a range of 1in. and a pitch of forty threads per inch. The drum is divided into 125 parts, so that one division corresponds to a movement of 0·0002in.

THE TESTING OF INVOLUTE GEAR TEETH

Apart from the accurate pitching of the teeth, the efficiency and general performance of a gear depends upon the degree to which the intended profile of the teeth is achieved during manufacture. Practically all gear teeth to-day

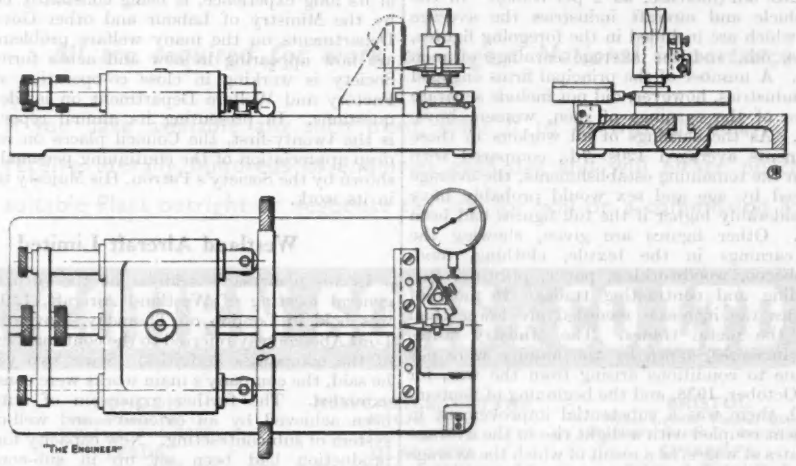


FIG. 13—ARRANGEMENT OF INVOLUTE PROFILE TESTING INSTRUMENT—DAVID BROWN

are made with involute profiles. This fact not only simplifies manufacture, by permitting the adoption of the "generating" process with its consequent reduction in the number of cutters to be carried in stock, but also permits the ready examination of the tooth profile by means of simple testing equipment.

An example of an involute profile testing instrument is that made by David Brown and Sons, Ltd., of Huddersfield, and illustrated in Figs. 13 and 14. The principle adopted consists of attaching to the gear wheel to be tested a "base disc" of the same diameter as the base circle of the gear wheel and of rolling the gear wheel across a horizontal surface with the edge of the base disc in contact with a straight edge. A stylus connected to a dial indicator is held in contact with the tooth profile

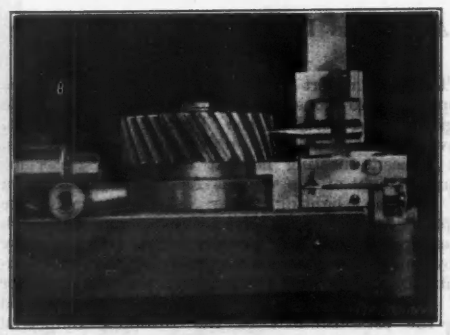


FIG. 14—INVOLUTE GEAR TESTING

during the rolling movement. By the geometry of the involute the dial indicator should show no movement during the rolling motion if the tooth profile is a true involute relatively to the periphery of the base disc.

The base disc is held between the straight edge and a hardened and ground circular steel rod resting against two roller bearings at the ends of two plungers. These plungers move in bushes in a slide which can be adjusted in position along the base plate of the instrument and clamped thereto in any desired position. At their ends remote from the ball bearings the plungers are coupled together with a tie bar with which a knurled nut and screw engage. By means of this nut the circular steel rod can be pressed against the base disc with the requisite degree of force. The base disc and the gear wheel attached to its arbor are rotated without slip by pushing or pulling the circular rod.

The stylus is mounted on a bracket which can be moved up or down and clamped to a triangular sectioned pillar rising from a carriage running on balls between it and a base block. The ball grooves are accurately parallel with the working face of the straight edge. A light spring in tension anchors the carriage to the base block and serves to hold the stylus in contact with the tooth profile. The plunger of the dial gauge makes contact with one end of the stylus carriage. Means are provided for setting the point of the stylus in the vertical plane of the straight-edge working face. These means consist of a cast iron angle bracket and a feeler piece one-tenth of an inch thick.

This apparatus has been submitted to the National Physical Laboratory, which has reported that "it is sound in principle, is well made, and seems to be free from errors of manipulation." A sample gear wheel submitted with the instrument was tested on it, and on the laboratory's own profile-testing machine. The two sets of readings showed "very close agreement." The instrument can be employed for examining the profiles of either spur or helical gear wheels.

The use of a "base disc," as in the above-described machine, implies that a different diameter of disc must be kept in stock for every diameter of gear wheel manufactured. While this fact may not be of serious moment, it is undoubtedly true that some manufacturers of gear wheels may prefer to employ an involute profile-testing machine which operates without a base disc, and which can be quickly adjusted to deal with gear wheels of any base circle diameter. One such machine is that made by the Fellows Gear Shaper Company, of Springfield, Vermont, U.S.A. This machine makes use of a master involute cam and by setting the position of the main slide by means of standard size blocks, the pointer which measures the involute is automatically located at the correct base circle radius. The master involute cam is developed from a base circle radius greater than that of the gear wheel corresponding to the maximum capacity of the machine. For checking gear wheels of smaller base circle radii, it is sufficient to change the radial distance of the pointer relatively to the axis of the gear wheel. The rate of travel of the slide carrying the indicator is, as a result, automatically changed to agree with the base circle radius setting. Provision is made for checking gear wheels with modified tooth profiles, a graduated dial being employed for this purpose in conjunction with the dial indicator. Another feature of the machine is that it can be used to determine the radius of a base circle when it is otherwise unknown. The machine can, if desired, be fitted with an electrical recording device, which presents a graph of the involute profile on a magnified scale.

PROFILE PROJECTORS

A system of gauging which entirely avoids the necessity for mechanical contact is that of optical projection. By its means work can be accurately gauged which, by using measuring instruments which depend upon mechanical contact, would be either exceedingly difficult or impossible to check. Particularly is this the case when checking plate gauges and form tools. Many other gauging operations which offer no serious obstacles to the use of mechanical testing equipment can be rapidly and efficiently carried out by profile projection.

A typical example of a profile projector is the "Taylor-Hobson" illustrated in Fig. 15. This machine is claimed to combine many features,

chief amongst which are the large screen image—5ft. diameter—wide range of magnification—×20 to ×100—and a large workfield combined with freedom from distortion.

The projector itself may be adapted to gauge a wide variety of different types of work. The profiles of plate gauges, form tools, screw threads, gear teeth, and a wide variety of other special work are projected on to the screen in magnified form, where the image may be compared either with a template formed from a master workpiece or with a carefully prepared enlarged-scale master drawing. It is claimed that the special characteristics of the "Taylor-Hobson" optical system enable accurate measurements to be made on the

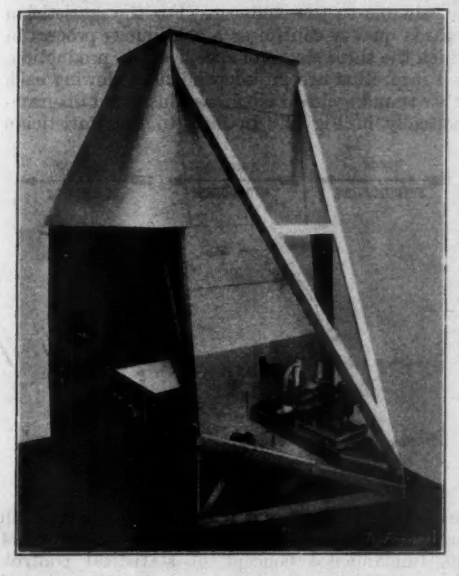


FIG. 15—PROFILE PROJECTOR—TAYLOR-HOBSON

screen. Screen measurements can therefore be accurately related to the work because the image is a faithfully magnified reproduction of the object.

The work is illuminated with a beam of collimated light; that is to say, a beam the rays of which have been rendered substantially parallel by optical means. This system of illumination is vitally important in producing on the screen accurate images. It is essential for carrying out exact measurement and comparison, particularly when projecting parts of substantial thickness. The magnified image is formed by means of a special projection lens. The magnification is governed by the focal length of the lens in use, and the image is of constant size to cover the 5ft.

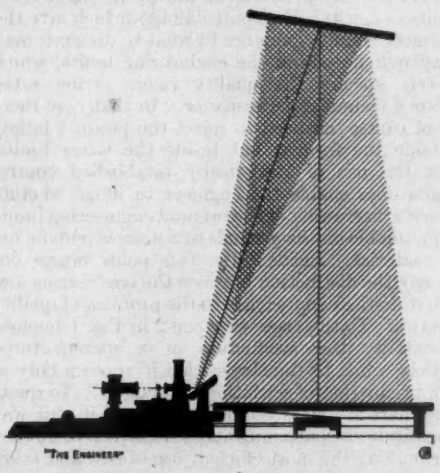


FIG. 16—OPTICAL SYSTEM OF PROJECTOR

screen. The workfields of the various lenses range from 3in. at ×20 to 0·6in. at ×100. Over this range the image is guaranteed to have a freedom from distortion not hitherto achieved in any projector. Thus, a combination giving ×50 magnification will cover a specified workfield with distortion nowhere greater than ±0·0002in., whether projecting profiles of thin flat plates or axial sections of screw threads.

The large screen image is obtained by using a long throw (approximately 17ft.), and the beam is reflected from two mirrors, as shown in Fig. 16. This keeps the structure of the instrument compact, and also enables a horizontal screen to be used, an arrangement which is of much help when measurements of the image are to be made.

The framework of the projector is sufficiently massive to render it immune to the effects of vibration, the mirrors are optically flat, and are metallised on the front face. The work table is of sufficient size to be capable of accommodating quite large parts. Movements are provided for placing the image suitably on the screen and are controlled remotely by three knobs beneath the screen. One of these knobs is used to focus the image, whilst the other two control the position of the image in two directions at right angles.

Accessory equipment is available in the form of special fixtures for holding centred work, plate gauges, and threaded parts. An auxiliary work table with a micrometer control provides tilting and swivelling movements, so that work can be presented at an inclination to the optical axis of the projector. Of special interest is the equipment for measuring screw threads. Axial sections of threaded work (magnified ×50) can be projected by means of a special thread lens, which allows the collimated illuminating beam to be inclined to the optical axis of the projector, so as to illuminate the thread along its helix. Thread-form measurements can be made accurately by this means. These measurements are greatly assisted by the use of standard thread-form templates in conjunction with a slip gauge carrier and screen micrometer. The slip gauge carrier enables a pair of lines to be projected on to the screen, at the same time as the image of the screw thread, the separation of the lines being controlled by means of slip gauges. Small discrepancies between the image and the drawing on the screen can be very accurately measured by means of the screen micrometer.

Profile projection provides not only a rapid means of accurate measurement for the gauge and toolmaker, but also a method for the rapid examination of mass-produced parts, in which connection it is of particular value when the work has several dimensions which must be gauged.

Various designs of projectors for optical gauging and inspection are made by Adam Hilger, Ltd., of London. In Fig. 17 we illustrate this firm's "Dekkor" inspection enlarger in one of its forms. It is a self-contained apparatus. The enlarged image is viewed directly with both eyes on an inclined translucent screen and is of such brightness that the instrument can be used in subdued light. A dark room is therefore unnecessary.

The instrument as illustrated in Fig. 17 is shown with the lantern arranged for the inspection of profiles. The object to be examined is placed on the work stage or special fixture immediately under the lamp-house and the image is formed on the sloping translucent screen, which is provided with a cross bar by means of which a transparent template can be clamped in position for comparison purposes. The reflecting system employed makes use of accurately worked mirrors, which are aluminised so as to retain their reflectivity for an indefinite time. The whole optical system is contained within a metal casing for protection.

The work stage consists of a mounting with a glass platform on which small objects may be placed for examination. This platform is provided with a vertical movement operated by a screw for focusing, the lens being so fixed that the magnification is correct when the projected image is sharply in focus. The platform may be swung to one side or entirely removed to permit the attachment of special fixtures. The lenses provided give magnifications of ×10, ×25, ×50 and ×100. The lamp-house gives parallel illumination for profiles and is adjustable for height and direction so that it can be inclined at an angle to suit the helix of a screw thread or for similar purposes. The lamp provided is of 48 watts at 12 volts. An illuminator for surface illumination can also be fitted to the instrument. This unit consists of a base casting, which is mounted on the flat top of the projector casing. On the base are two adjustable arms carrying two lamp-houses, each fitted with a 48-watt lamp. The light is projected downwards on to two mirrors in the base of the unit and is then reflected upwards

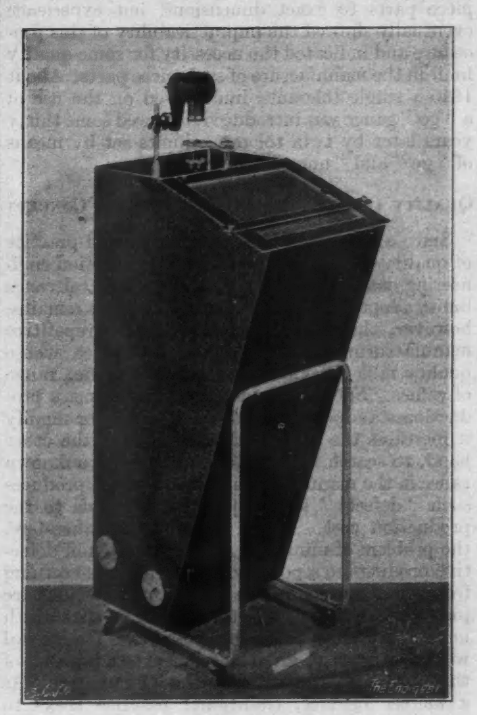


FIG. 17—"DEKKOR" INSPECTION ENLARGER—HILGER

on to the surface of the work, which may be mounted on the platform of the projector or on a special fixture.

For the inspection of screw threads the Wilson projection gauge, also made by Adam Hilger, Ltd., is of especial interest. Instead of projecting only one profile image of the screw as in ordinary practice, this instrument projects two diametrically opposite profiles. The optical system is so arranged that the images fall exactly into register if the diameter of the screw is correct. If the dimensions or thread shapes are not correct the two images will either not come together or will overlap and the gap or the overlap will indicate the error in size. It is thus possible for an unskilled operator to determine at a glance the accuracy of all the dimensions of a screw. It is stated that on one of these machines 700 pieces have been gauged in an hour at a Government factory.

(To be continued)

Statistical Methods in Engineering Practice

No. II—QUALITY CONTROL IN PRODUCTION ENGINEERING

By H. RISSIK

(Continued from page 342, November 29th)

THE fact that Man is, among other things, a rational animal is evidenced by the increasing technical complexity of the successive civilisations which he has raised throughout the so-called historical period of his existence. The basis of all civilisation is ultimately material. Although we like to think that we are in every way superior to our palæolithic ancestors, whom in our ignorance we dub as "savage," that superiority has only been proved in the sphere of technology. In fact, technological development is merely the visible manifestation of Man's increasing control over Nature. Moreover, that wide area of technology which we term "engineering" is nothing other than the technique of wringing material benefits from Nature by means of tools. Even in the early food-gathering stage of pre-history, Man knew how to fashion primitive tools out of stone, while his neolithic successors made flint axes and bone harpoons with quite considerable skill. By the time Man reached the food-producing stage of material development and therewith the beginnings of agricultural civilisation, that is to say, some 10,000 years ago, his engineering technique had progressed to the point where he had invented the wheel and had learned to fit parts together in a crude way. Under these primitive technological conditions the control of quality in his artifacts perforce remained a matter of personal skill aided by artistic judgment.

The next radical step in quality control was not taken till some 150 years ago. Although it would seem that in the early Bronze Age, about 5000 years ago, the Egyptians had succeeded to a limited extent in producing interchangeable bows and arrows, the principle of interchangeability of component parts made little headway until the Industrial Revolution in the late eighteenth century. The application of this revolutionary engineering principle, on which is founded our present technology of mass production, was from the outset bound up with the concept of exactness—a legacy from Newtonian mechanics—which then held sway in the realm of science. As the result, attempts were made to produce interchangeable piece parts to exact dimensions, but experience eventually showed the impracticability of this procedure and indicated the necessity for some quality limit in the manufacture of such piece parts. About 1840 a single tolerance limit based on the use of a "go" gauge was introduced, followed some thirty years later by twin tolerance limits set by means of "go" and "not go" gauges.

Quality Control as an Engineering Concept

Since about 1870, then, the traditional practice of quality control in the sphere of production engineering has been one based on the actual tolerance limits adopted in manufacture. The fact remains, however, that every now and then a repetitive manufacturing process yields a product whose quality falls outside the specified tolerance range of values. Such a product is, from the mass production standpoint, defective. To scrap or modify it increases the cost of production. On the other hand, to search for and to eradicate the unknown cause in the manufacturing process which produces such "defects" (or "rejects") also adds to the production cost. There has remained, therefore, the problem of minimising the proportion of defective products to a point where the savings accruing from the reduction in the number of rejections are just offset by the cost of the control process which makes any such reduction possible. Traditional workshop practice gives no solution to a problem of this nature, other than that of trial and error. As a matter of fact, traditional practice seeks to employ the widest possible manufacturing tolerances compatible with good technical performance. Assuming that under these circumstances the manufacturing process yields a product whose quality always falls inside the given tolerance range of values, is there any point in narrowing the limits? To leave well enough alone is generally considered sound workshop practice. Technically, this view is no doubt quite correct; but it overlooks the fact that, other things remaining equal, narrower limits mean a more economic use of materials and components. Because, in so far as a narrowing of the tolerance limits connotes an improvement in quality of the product, a lower "factor of safety" may be adopted in designs. As a matter of fact, it is this consideration, more than any other, which renders the hand-made product superior to the corresponding mass-produced article. Here, again, the problem is to know how far it is economic to go in this direction. Traditional practice, when it recognises the problem at all, can only furnish a solution in terms of trial and error.

Lastly, consider the case of a manufacturer who somehow fails to establish control over the quality of a piece part within the specified tolerance limits. For some reason or other, and in spite of all efforts to remove causes of excessive variation, the proportion of his output which must be classed as defective remains too large. He is left with no alternative, but to inspect each unit of product and to fall back on individual and selective assembly as a substitute for mass-production assembly based on the principle of interchangeability. Nevertheless, the question remains. Has everything, in fact, possible been done to eliminate the causes of excessive variation, or is there some technique beyond the ken of traditional workshop practice that might still enable him to gain control of the quality of his product within the given tolerance limits? This question is, above all, the crucial one in mass production, for it only arises after methods of trial and error, the last refuge of traditional engineering practice, have been attempted without avail. Not till 1924 was the answer found. Shewhart's novel statistical technique embodied in the so-called quality control chart has proved a most valuable tool in the hands of the production engineer. But, more than that, Shewhart's pioneer work in this field has served to develop the statistical approach to many problems of mass production, particularly the two economic problems mentioned above. This approach is based on the concept of statistical control—a concept which we have already encountered in our previous discussion of the statistical nature of the physical world.[1]

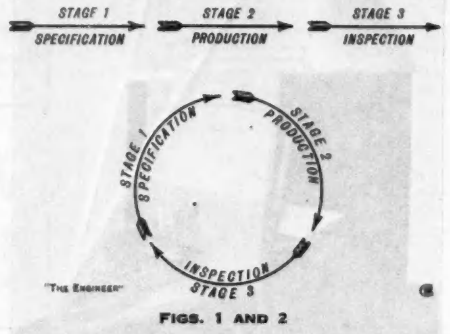
The Statistical Basis of Quality Control

The statistical approach to quality control—by which term is to be understood the conscious shaping of a material quality characteristic towards some desired end—is, then, a very recent development in the progress of mass-production engineering. And the use of statistical methods as an aid to quality control has brought to the fore two considerations of fundamental importance that have generally been glossed over. First, it is to be remembered that the quality of a manufactured product is determined, in the last analysis, by human judgment, and thus inevitably has a subjective aspect. Secondly, it is evident that before quality can be discussed objectively, means must be available for determining it and expressing it. In the engineering sphere at any rate, the quality of a manufactured product, whether in the raw material, semi-finished, or finished state, is a perfectly determinable characteristic that may take one or other of two forms. These two types of quality characteristic are termed by the statistician attributes and variables respectively. In the case of attributes the quality scale is discontinuous. The product either possesses the particular attribute or it does not; and its quality is expressed accordingly. For example, an electric lamp may be classed as defective or non-defective according as to whether the filament is broken or not. In the case of variables, on the other hand, the quality of the product is expressed directly as a reading on some continuous scale of measurement. For example, when considering an aluminium alloy for use in aircraft construction its quality—its fitness for the purpose in hand, or "goodness," in other words—may very well be defined in terms of tensile strength.

Generally speaking, the engineer deals with variables rather than with attributes, so that the quality of the products with which he is concerned can be expressed by direct measurement. (It sometimes happens that from the statistical standpoint, it may be more convenient to treat the variable quality characteristic as an attribute, by specifying a certain limiting value of the variable which shall form the line of demarcation between a defective and a non-defective product. As will be shown later, this applies particularly to inspection procedures.) Thus, from the engineering standpoint, the operation of quality control is mostly a matter of controlling variability in some directly measurable quantity. In practice, this entails analysing the observed variability and comparing it with some objective standard. It is the function of the statistician to provide the engineer with this standard of variability. For the statistician's yardstick is random variation, which, from the aspect of quality control, is the particular variability encountered when the variations in quality of the manufactured product arise solely from the operation of a constant system of chance causes. In other words, the objective standard of variability to which the production engineer has to work is that associated with what Shewhart has termed a state of "statistical control." If this state exists in the manufacturing process, then it is possible to specify limits within which all, or very nearly all, of the observed values of the variable quality characteristic are expected to lie. Thus, if a series of observations on quality—such as the results of tests made on samples drawn at random from a batch of the product—are found to give values lying outside these limits, then it is reasonable to assume that the manufacturing process is not in a state of statistical control. That is to say, under these circumstances the engineer is justified in looking for assignable causes of variability in his manufacturing process. Although the variation in the observed values may, on the whole, appear to be random—produced by a constant system of chance causes, in other words—the engineer has no means of satisfying himself on this vital point, except he resort to statistical technique. For only then is he in a position to visualise, and to establish numerically, fixed limits outside of which a purely random variation becomes so improbable as to be practically impossible.

Quality Control as a Unity of Theory and Practice

From the engineer's essentially practical point of view, quality control appears as a more or less discontinuous process, occupying three successive stages—specification, production, and inspection. The designer specifies what is required, the production engineer takes the specification as a guide to manufacture, and the inspector judges whether or not the manufactured product complies with the requirements of the specification. In traditional engineering practice these three stages are virtually independent, as shown diagrammatically in Fig. 1, except that under up-to-date conditions of mass production the inspection results obtained in stage 3 are used in a general kind of way to initiate adjustments in stages 1 and 2. Even then there is seldom any conscious idea of quality control lying behind traditional practice in this respect; the process of feeding back information obtained from inspection is not directed in a positive manner. It is precisely here that the statistical approach is so valuable to the engineer. For the statistician regards quality control as a continuous process in which the three stages of specification, production, and inspection are interdependent, following each other round a closed circle, as illustrated diagrammatically in Fig. 2. In fact, to the statistician



FIGS. 1 AND 2

these three successive stages of quality control in production engineering are really three aspects of his fundamental concept of statistical control. Specification represents a *state* of statistical control; production, in turn, represents an *operation* performed to attain this state; and, finally, inspection represents a *judgment* as to whether o not that state has been reached.

The statistical approach to quality control thus commences with the specification of manufacturing tolerances or "engineering limits" (stage 1), followed by the mathematical operation of setting up statistical tolerances or "control limits" whose transgression constitutes evidence for believing that the manufacturing process includes assignable causes of variation in quality that may give trouble in the future if they are not found and removed (stage 2). The manufactured product is finally inspected and the observed values of quality are examined to see to what extent they lie within the control limits, as well as within the engineering limits (stage 3). The control limits, which give the engineer definite guidance in what to do next, may very well lie within the engineering limits, which merely specify the quality range giving satisfactory technical performance. In that case there is, of course, no need to reject the product falling outside the former, but inside the latter limits. But the use of statistically established control limits does enable the engineer to judge whether or not a narrowing of the original engineering limits is justifiable on the grounds of a more economic use of material. Incidentally, this point brings out clearly the distinction between the engineering and the statistical approaches to the problem of quality control. To the engineer stage 2 in Fig. 1 remains essentially the production of a manufactured article, while to the statistician it appears only as the production of variations in quality. To quote Shewhart: "Mass production viewed in this way constitutes a continuing and self-corrective method for making the most efficient use of raw and fabricated materials."

Theoretical Principles Underlying the Control Chart

The first step in quality control, then, is the specification of tolerance limits which are attainable in practice. It is obvious that this cannot be done out of the blue; the specification must take into account the given manufacturing conditions, which are implicit in the production process and which are not revealed until inspection of the product takes place. At the outset, therefore, the production engineer is caught in a vicious circle. But he can break it by taking the as yet unknown manufacturing conditions as given and by inspection of the product over a considerable period of time so obtain a series of values of its quality. (It may here be observed that if the quality characteristic is an attribute (viz., the fraction or percentage of the

product classed as defective), these values are obtained by counting. If the quality characteristic is a variable (*e.g.*, tensile strength, electrical resistance, lamp life, percentage ash content of coal), the values are obtained by measurement. This practical distinction between the two types provides a convenient means of classifying quality characteristics). Having obtained such a sequence of quality values, the engineer's next task is to systematise and analyse this quantitative information with a view to determining whether or not the observed variation in quality is random, that is, due to a constant system of chance causes operating within the production process. This task is essentially of a statistical nature and involves a relatively simple technique leading to the convenient pictorialisation of the inspection data developed by Shewhart[2] and known as the quality control chart.

A statistical examination of such a series of observations at once reveals the existence of a certain relation between particular values of the quality characteristic and the frequencies with which they occur. This relation is termed a frequency distribution and is shown diagrammatically in Fig. 3.[3] In the typical case illustrated here the particular variable selected as a measure of quality is the average value of a number of observations taken at a given time, viz., the average quality value of a sample drawn from a batch of product. It will be observed that the greater the number of observations—in this case the greater the size of the sample—the more regular does the distribution of the variable become, and that as their number tends to infinity the distribution approaches towards a smooth curve, termed a frequency curve. These particular conditions illustrated by Fig. 3 indicate that the manufacturing process has already reached a state of

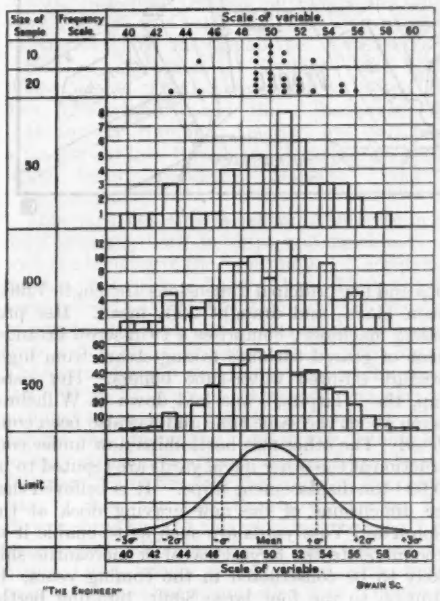


FIG. 3

statistical control, in which the quality of the product exhibits a purely random variation. The frequency curve is, in fact, the so-called normal curve, representing the Gaussian frequency distribution (or law of error), whose equation is

$$F(x)=\frac{N}{\sigma\sqrt{2\pi}}\exp\left[-\frac{(x-\bar{x})^2}{2\sigma^2}\right] \quad . \quad . \quad (1)$$

where N is the total frequency, *i.e.*, the total number of observations of the variable (=quality characteristic) x, and $\bar{x}$ is the average of the N values of x, viz.,

$$\bar{x}=\frac{1}{N}\sum_1^N x \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

while σ is their *standard deviation* defined by

$$\sigma=\sqrt{\left[\frac{1}{N}\sum_1^N (x-\bar{x})^2\right]} \quad . \quad . \quad (3a)$$

$$=\sqrt{\left[\frac{1}{N}\sum_1^N x^2-\bar{x}^2\right]} \quad . \quad . \quad (3b)$$

and is, in fact, the root-mean-square value of the N deviations of x from the average $\bar{x}$.

The unique feature of the normal distribution expressed by (1) is that it is completely defined by the two parameters $\bar{x}$ and σ. The former is a measure of the central tendency of the N observations, while the latter is a measure of their dispersion or spread about the central value. (In the language of the engineer, $\bar{x}$ is the "centre of gravity" of the frequency curve, while σ is its "radius of gyration" about an axis through $\bar{x}$.) If we are free to assume that a manufacturing process is in a state of statistical control—which in theory we are not, but in practice, and in the absence of information to the contrary, we are—then we can use equations (2) and (3) to condense the data obtained as the result of inspection, in the knowledge that the parameters $\bar{x}$ and σ preserve for future use all the statistical information contained in the original N observations. The use to which the average and standard deviation of such an observed frequency distribution can be put becomes apparent when we consider for a moment the nature of a distribution function. It can be shown that the total area under the frequency curve expressed by (1), that is the area between the limits $-\infty<x<+\infty$, is equal to the total frequency N. (As a matter of fact this is true of any distribution function or frequency curve.) Also, and what is more important, the area under the curve between any two limits x_1 and x_2 gives the number of observations lying within that range. In the limit, when the range is from $(x-\frac{1}{2}dx)$ to $(x+\frac{1}{2}dx)$, the frequency with which any value x occurs is given by the element of area $F(x) \,.\, dx$ and the relative frequency of x is thus $dp=F(x) \,.\, dx/N$. For any specified range of values of the variable x the proportion p of the total number N falling within this range is therefore given by the fundamental relation

$$p=\frac{1}{N}\int F(x) \,.\, dx \quad . \quad . \quad . \quad . \quad (4a)$$

$$=\int \phi(t) \,.\, dt \quad . \quad . \quad . \quad . \quad (4b)$$

where $\phi(t)$ is the normal distribution function in its generalised form, viz.,

$$\phi(t)=\frac{1}{\sqrt{2\pi}}\epsilon^{-\frac{1}{2}t^2} \quad . \quad . \quad . \quad . \quad (5)$$

in which t is the so-called generalised deviation defined by the ratio

$$t=\frac{x-\bar{x}}{\sigma}=\frac{\text{individual deviation}}{\text{standard deviation}} \quad . \quad . \quad (6)$$

Equations (4*a*) and (4*b*) are related by $F(x)=(N/\sigma) \,.\, \phi(t)$. The generalised normal curve is symmetrical about the maximum ordinate at $t=0$, whose value is $1/\sqrt{2\pi}=0{\cdot}399$. The total area under the curve is unity. Standard tables are available of the function $\phi(t)$ and of its integral, as given by (5) and (4*b*) respectively.

The characteristic feature of this unique law of random variation is that almost the whole area under the frequency curve is included in the range $t=\pm 3$, in spite of the fact that the total range is from $t=-\infty$ to $t=+\infty$. Expressed in terms of equation (1), this means that practically all of the N observed values of the quality characteristic x are included in the range $x=\bar{x}\pm 3\sigma$. The proportion p falling within the range $x=\bar{x}\pm t\sigma$ is given for a few values of t by the following tabulation. The ordinates to the normal

t.	p.
4	0·99995
3	0·9973
2·576	0·99
2·326	0·98
2	0·9545
1·96	0·95
1	0·683
0·6745	0·5

curve for the first three integral values of t are shown in Fig. 3, for which, incidentally, $\bar{x}=50$ and $\sigma=3{\cdot}3$.[4] It is this fundamentally statistical relation between t and p—between a given range of variation and the proportion, falling within this particular range, of the countless individual variations produced by a constant system of chance causes—which is the theoretical foundation of the

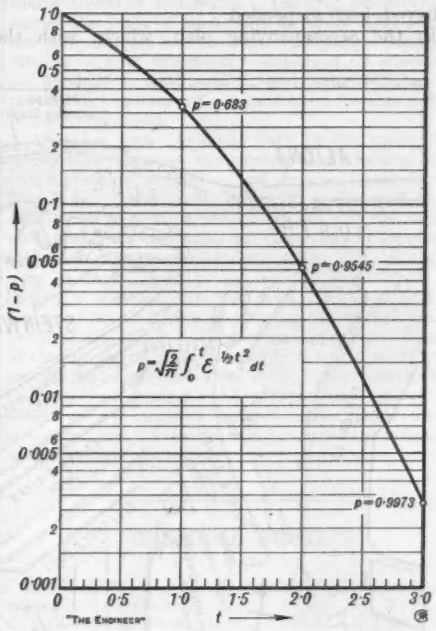


FIG. 4

quality control chart developed by Shewhart. The complementary relation between t and $(1-p)$ is shown in Fig. 4.

REFERENCES

[1] See Part I of the present article, entitled "Fundamental Aspects of Statistical Technique," which appeared in THE ENGINEER, November 29th, 1940.

[2] *Vide* W. A. Shewhart's "Economic Control of Quality of Manufactured Product," Chapters XIX and XX (McMillan and Co., London, 1931).

[3] Examples of frequency distributions for a wide variety of quality characteristics encountered in engineering practice are to be found in a recent paper by B. P. Dudding and W. J. Jennett, entitled "Statistics in Engineering Practice" (*I.E.E. Journal*, Vol. 87, July, 1940, page 1).

[4] This particular illustration has been taken from E. S. Pearson's "Application of Statistical Methods to Industrial Standardisation and Quality Control," published by the British Standards Institution as B.S.S. No. 600—1935. This publication is an almost indispensable guide to the subject of statistical methods in engineering practice. The same remark applies to the "A.S.T.M. Manual on Presentation of Data," issued by the American Society for Testing Materials. The latter, in particular, is a veritable storehouse of practical information on this subject.

(*To be continued*)

Air Force Targets in Germany

No. XIV

(*Continued from page 344, November 29th*)

THE PORT OF HAMBURG AND ITS SHIPBUILDING INDUSTRY

FEW places in Northern Germany have been attacked more frequently by machines of the Royal Air Force Bomber Command than Hamburg and the important industrial establishments which are to be found in and around that great port. The record which is provided by the Air Ministry Bulletins shows that the first attacks were made early in May, and they have continued at short intervals up to the present time. Several times each month on consecutive days the main targets have included docks and harbours, oil storage tanks and depôts, barges and shipping, oil refineries, shipbuilding and engineering establishments, power stations and warehouses. Hamburg is important as a target on account of the position it holds as a transhipment port for the North Sea and the Baltic Sea, and the centre it forms for the flow of manufactured goods, which come from a great railway network, the new motor roads, the rivers Elbe and Vistula, and the many inland canals. The port of Hamburg has a history which extends over half a century and in 1938 it celebrated its semi-centenary both as a Free Port and its entry into the German Customs Union.

In the early days the port was of a comparatively simple character, with a few dolphins at which sailing ships used to lie along the stretch of city embankment which ran from the Johannesbollwerk to the Baumwall in the Lower Harbour. With the passing years the port was increased in size and new docks were added, with modern crane equipment and warehouse accommodation. The port of Hamburg suffered during the last war, but it rose again and by 1938 had reached the fourth place among European ports, the order then being Rotterdam, 44·6 million tons of goods tran-

shipped; London, 44·4; Antwerp, 28·4; and Hamburg, 25·3 million tons. That increase was helped by the low water regulation of the River Elbe, the connecting of the Mittelland Canal with the Elbe, and the construction of the Hansa Canal, giving connections from Hamburg to the Ruhr district. A north and south connection between the Mittelland Canal and the Rhine-Maine-Danube waterway also facilitated further Hamburg shipping trade. The completion of various motor roads around Hamburg also played their part, and in conjunction with the new roads a large collecting warehouse for export piece goods was built with access to road, rail and shipping. Below Hamburg, between Altona and Blankensee, a large suspension bridge to carry the new motor road over the Elbe was planned, and the foundations were laid, but work on this project has, it is believed, been suspended.

In the accompanying plan, which, with the permission of the Hydrographer of the Admiralty, has been based on part of Admiralty Chart No. 3262, we show the general lay-out of the harbours of Altona and Hamburg. The port itself and its modern crane and warehousing arrangements have been the subject of many papers by its harbour engineers and is well known by dock authorities. In this connection it is sufficient to record that an extensive use has been made of piers built on piles, and dolphin constructions which have enabled double-sided quays to be arranged and equipped for different classes of ships. A division is made between the Free Harbour and the Customs Harbour, which are separated by barricades.

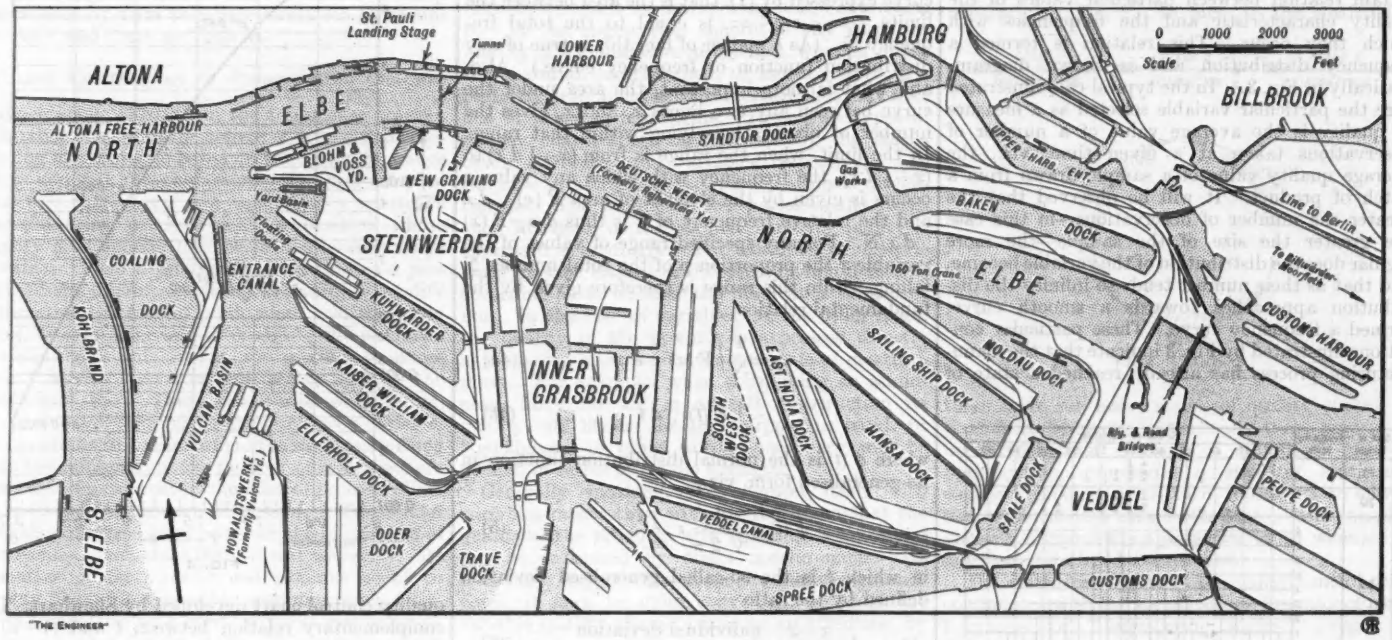
Some particulars of the port will indicate its size and importance. Its distance from the Elbe No. 1 lightship is 86 miles, and it is 64 miles from the port of Cuxhaven. The river reaches a maximum width of 2000ft. at Finkenwärder, just before it divides into the North and South Elbe at Altona, and at the point where the railway and road bridges are built it has a width of about 1000ft. These bridges, which were constructed some time ago, have each three 300ft. spans, a technical feature of the early bridges being the use of Lohse girders. They were built between 1868 and 1872. The road bridge, some 650ft. higher up the river, was constructed in 1892, and that connecting the Free Port with the docks in 1926. Another interesting engineering feature is the Elbe tunnel, which was built to save a detour of 7½ miles. The two shafts serving the two under-river subways each have a depth of 76ft. and a diameter of 72ft. They are equipped with six lifts, capable of dealing with loads up to 10 tons. The subways are designed for one-way traffic and have a diameter of 19ft. 6in. They are placed at 26ft. centres. Each subway has a roadway and two side footpaths. The depth of water at Hamburg is about 40ft. and there is about 17ft. of earth over the tops of the subways.

The greatest length of harbour area, measured at midstream, is about 9 miles and the area of the harbour, including the Free Port, the Peute dock area and the Billwärder-Moorfleth areas, is over 10,000 acres. In the various docks and harbour basins depths of water from 24ft. to 36ft. are available. The total lengths of quays for sea-going ships is over 20½ miles and 18½ miles in the Free Port, the same figures for the river craft being 10 miles and 3½ miles respectively. There are ten large cranes and over 650 transportable cranes, besides coal and ore loading plants, dredgers and barges, &c.

Two Intensive Air Attacks

The scope of the present article will not allow us to discuss in detail the many air attacks made on the port and its surroundings, to which we have already referred. Mention, however, may be made of two of the outstanding raids, which were carried out on Friday night and Saturday morning, November 15th–16th, and Sunday night, November 24th. In the first of these raids an attack was made on the riverside districts which, it is reported, suffered greatly. Soon after dark an attack was carried out by medium bombers on the Rhenania-Ossag mineral oil works at Harburg-Wilhelmsburg, which lies immediately to the south of the district, shown in the lower part of our map. At this part of the South Elbe railway goods yards were attacked and also the Schlink factory for the manufacture of edible oils and fats. Later the various targets in the Billwärder and Moorfleth districts of Hamburg itself suffered attack for nearly two hours, during which 1000 incendiaries were dropped. The large railway yard in this district, which is indicated on our map, was also attacked with incendiary and high-explosive bombs. Later other bombers attacked industrial works in the Altona district, including a mineral oil factory, while a heavy attack was made on the Blohm and Voss shipyards, not far away, on the other side of the North Elbe. Other industrial areas attacked included those of Veddel and Peute, to the south of the Elbe.

The most serious attack on the Blohm and Voss yards was that carried out on November 24th. In the first attack, which took place between 7 p.m. and 8 p.m., many tons of high-explosive bombs and nearly 2000 incendiary bombs were dropped on the vast acreage of the yards which stretch along the Elbe. Particular attention was paid to the new graving dock for the dry docking of the largest naval and mercantile ships. The approximate position of this new dock is indicated on our map, and it will be seen that it is not far from the Elbe tunnel. Some idea of the size of the dock can be obtained from the battleship "Bismarck," which, it is reported, has been recently completed by the firm. She was laid down in 1936 and was launched on February 14th, 1939. Her displacement is 35,000 tons and her principal dimensions are length 729ft., beam 118ft., and draught 26ft. mean. Her propelling machinery comprises a twin-screw arrangement of geared turbines taking steam from high-pressure oil-fired water-tube boilers. Her sister ship, the "Tirpitz," was laid down at Wilhelmshaven about the same time and has also been completed. The other two battleships now under construction at the other naval yards are reputed to be 40,000-ton displacement ships. It is believed that the dimensions of the new graving dock at the Blohm and Voss yards are such as to enable it to accommodate the largest naval or mercantile ship likely to be constructed in the coming years. In addition to the four large 800ft. building berths and the smaller 400ft. berths, some of which are covered berths, the firm possesses, or did possess,



MAP OF HARBOURS OF ALTONA AND HAMBURG

THE MAIN ELBE BETWEEN ST. PAULI AND GROSSER GRASBROOK

a fine block of administrative offices and large and well-equipped shipyard works and boiler and engine shops. Repair work at this particular yard is carried on in no less than eight floating docks, while not far from the main works are new shops which are set apart for the construction of "BV" type aircraft and flying boats. Other important targets in the Altona and Hamburg areas included the municipal gasworks, shown in one of our illustrations, and power stations both at Hamburg and at Altona. Several photographs of Hamburg are reproduced on page 362.

HAMBURG'S SHIPBUILDING INDUSTRY

With the rise of Hamburg as a port its shipbuilding and engineering industry has prospered. The oldest yard is that of the Reiherstieg Schiffswerft und Machinenfabrik, which is now in the possession of the Deutsche Werft. It was founded in the middle of the nineteenth century by the firm of Godeffroy and Sohn, and specialised in the construction of iron ships and their machinery. The crane equipment of the yard was very advanced and has been copied by other Hamburg yards. This company has built important passenger and cargo ships for the leading Hamburg shipping lines. Quite near to this yard is that of another old shipbuilding firm, H. C. Stülcken and Sohn, which was established in 1846. It has specialised in the building of smaller ships, such as fishing craft and whaling ships. A smaller yard in the Upper Grasbrook area is that of the Norderwerft, which also builds fishing craft.

The largest Hamburg shipyard belonging to a private firm is that founded by Hermann Blohm and Ernst Voss in 1877. In the early days this yard built ships from English plates, and early in its career it had many liners and cargo ships for foreign service to its credit as well as naval ships. During the last war and in the years previous to it many important German battleships and cruisers were built at this yard, and also destroyers and submarines. We may recall the "Von der Tann," "Moltke," "Goeben," "Seydlitz" and "Derfflinger," some of which were sunk at Scapa Flow. The "Vaterland" and the "Bismarck" were built for the Hamburg-Amerika line and passed after the war into British and American ownership, being known as the "Majestic" and the "Leviathan."

This yard has always taken an interest in new developments, both in ships and machinery and with the building of the "Secundus" it constructed its first motorship. Later, about 1910, the firm arranged with the M.A.N. Company, of Augsburg, to construct double-acting two-stroke oil engines, with which many successful ships were engined. The first motorship with this type of machinery was the "Fritz." Turbine machinery was also constructed at an early date to Parsons and A.E.G. designs and among the outstanding turbine ships we may mention the North German Lloyd liner the "Europa," and the four fast ships of the "Hamburg" class for the Hamburg-Amerika Line. Recent ships built at this yard included the "Pretoria" and "Windhuk" for the German East Africa Lines, which are equipped with Benson boilers and the electric propelled liner "Potsdam" for the Far East service of the German lines.

Another famous Hamburg yard is that of the Vulkanwerke, which since 1911 has been associated with Hamburg, and built, among other famous ships, the "Imperator," which later became the "Berengaria." At this yard several large liners for Hamburg services and other lines were built and engined. Particularly interesting was the hydraulic mechanical drive developed by this yard to the designs of Dr. Föttinger, and later Dr. Bauer. In 1926 the yard was taken over by the Deutsche Schiff und Maschinenbau A.G. Weser. Later it was acquired by Dr. Diederichsen, who had previously bought the yard of Janssen und Schmilinsky. When the Vulkan interests were amalgamated with those of the Howaldtswerke, of Kiel, the shipbuilding portion of the business was left at Hamburg and the engine works transferred to Kiel.

One of the later yards and engine works which has greatly increased in size and importance during recent years is the Deutsche Werft, which was first formed shortly after the war to build ships and oil engines at Finkenwärder. The firm was sponsored by the A.E.G. Company of Berlin, and the Gutenhoffenshütte of Sterkrade. Many fine ships were built both for German and foreign lines. They included tankers and cargo vessels and five cargo carriers being built to British account for the Prince Line. The Deutsche Werft has carried out considerable development work on oil engines, electric propulsion and the Simplex balanced rudder. A few years ago the company acquired the Reiherstieg yard for repair work and ship and engine construction.

No reference to the shipbuilding industry in Hamburg would be complete without some mention of the work on the scientific side which has been carried out by the Hamburg Experimental Tank, under the direction of Dr.-Ing. Gunther Kempf. The largest tank has a length of 1194ft., a maximum width of 52ft., and a maximum depth of 222ft. It has carried out work for many firms both in Germany and abroad, and has been aided in its work by the Society of Patrons and Friends of the Tank, which was founded by Dr.-Ing. E. Foerster, who arranged many International Meetings, the last of which took place at Hamburg, Kiel and Berlin in the summer of 1939.

Sixty Years Ago

MARK FIRTH

ON November 16th, 1880, Mr. Mark Firth, head of Thomas Firth and Sons, Norfolk Works, Sheffield, died after a brief illness. He was the eldest of the five sons of Thomas Firth, and was born at Sheffield in 1819. His father, Thomas, was the chief steel melter at the works of Sanderson, Brothers and Co. In 1833, when Mark left school, his father obtained for him a place in Messrs. Sanderson's office. Even at that early date he was remarkable for his habits of order and method. One of the first things which he did on entering the office was to write in large letters and post up a placard bearing the words "A place for everything and everything in its place." After a time his younger brother Thomas joined his father at the melting furnace and soon became so proficient that he was able to do all the "teeming" and heavy work, leaving his father free to confine himself to superintending. At that time the father's wages were £3 10s. per week, while each of the sons received £1. About 1842 the father applied for a rise in wages. It was refused. The refusal offended Mark more than his father. Mark made up his mind to leave and urged his father and brother to do likewise. The father was reluctant to do so, but Mark's masterful way carried the point. The three Firths set up business on their own account with a six-hole furnace in Charlotte Street. Indomitable perseverance and energy brought the new firm prosperity and before many years had passed it was a serious competitor of Messrs. Sanderson in the home market. It acquired, too, a large American connection, which compelled it to enlarge its manufacturing resources. In 1849 it leased from the Duke of Norfolk fifteen acres of land in Saville Street, where it erected the Norfolk Works, which to this day are famous the world over. The father died in 1848 and the brother Thomas in 1858. From then onwards Mark continued to conduct the business with ever increasing success. His business capacity went hand in hand with a strong and practical sympathy with the workers in the industries of his native town. His beneficence gave the city Firth Park, Firth College, Firth's Almshouses and other public works. During the last twenty years of his life he was said to have spent £200,000 on public and philanthropic purposes. On the day of his funeral places of business in Sheffield were closed, the streets were lined with people and among those who followed his body to the grave were 700 workmen, representing the many employed in the great establishments of which he was the able and honoured head.

Chrome Ore and Chromium

ANOTHER new volume* has just been added to the series of monographs on mineral resources issued by the Imperial Institute. It is a book of 118 pages on chrome ore and chromium, which, like the others in this series, covers every aspect of the nature, occurrence, and utilisation of the mineral with special reference to the deposits in the Empire, which are both numerous and of high grade. Some measure of the rapidly increasing use of chrome ore may be gathered from the fact that the world's output rose from less than a quarter of a million tons to more than 1 million tons during the period between the close of the war of 1914–18 and the outbreak of the present war.

Chromium is a metal of great importance in peace time and of vital importance in war on account of its employment in a very wide range of steels, non-ferrous alloys, refractories, and in numerous chemical industries such as tanning, dyeing, pigments, and chromium-plating. It is mainly employed for metallurgical purposes, especially in the production of stainless steels, for steels used in the construction of light-weight structures of great strength, and in the manufacture of steels for various chemical and food industries. There are also the very important heat-resisting nickel-chrome steels which grade into the nickel-chromium resistance alloys widely used as wire or strip for electrical heater elements, and many non-ferrous alloys of which stellite is an outstanding example.

Scarcely less important from the point of view of tonnage consumed are the refractories based on chrome ore. Modern methods of steel production call for improved refractory linings for furnaces, and these are being met to an increasing extent by the use not only of chrome bricks, but of composite refractories such as chrome-magnesite bricks which possess greater refractoriness under load and improved resistance to spalling. Lesser amounts of chrome ore are employed in making dichromates, chromic acid, and the various chromium salts required in many chemical industries. Tanning probably consumes the bulk of such salts as most light leathers are now tanned in this way. Although chromium-plating is now extensively employed on account of its decorative, anti-tarnish, and wear-resisting properties, the amount of ore consumed for this purpose is relatively small.

All these uses are dealt with in the monograph, which also discusses the mining and dressing of the ore, marketing and prices, and the world's production. The bulk of the book, however, is devoted to the occurrence of chrome ore, both in the British Empire and foreign countries, no less than forty-three different countries being dealt with. The Empire is very strongly situated as regards supplies of this strategic mineral, for Southern Rhodesia and the Union of South Africa are among the world's leading producers. India, too, possesses important deposits of chrome ore of good metallurgical grade, and Cyprus and Sierra Leone also contribute to the total output. In fact, just prior to the present war, about one-third of the world's output came from British countries, and two-thirds was produced by companies under British control.

* "Chrome Ore and Chromium," by Robert Allen, M.A., B.Sc., and G. E. Howling, B.Sc. (Imperial Institute, South Kensington, S.W.7; 118 pages; 2s. 6d. net, postage 4d.).

TECHNICAL REPORTS

A Critical Study of the Application of Electricity to Agriculture and Horticulture. E.R.A. Report, Ref. W/T2. By C. A. Cameron Brown, B.Sc., A.M.I.E.E. 1940. Price 2s. 5d. post free.—This critical study has been prepared by the British Electrical and Allied Industries Research Association as a starting point for its researches into the various applications of electricity to agriculture operations. It quotes widely from reports of researches from all over the world. The subject is introduced by a general section on the issues affecting supply, and then the various applications of electrical energy are considered in detail. The difficulties confronting ploughing and heavy cultivations are outlined, but the conclusion drawn is that, in the event of conditions calling for an active solution of the problem the technical difficulties could be solved. Barn power is dealt with as a comparatively straightforward application which raises few problems calling for research, other than experimental investigation into the improvement of load factor and further elimination of manual labour. Electrical power in dairy farming brings problems more economic in character, and research is required to develop the labour-saving aspects of electrical operation to the full and also to improve the methods of loading so as to encourage low tariffs. Work already carried out in this direction is described. Poultry farming brings in such technical complications as the effect of supply failure on eggs and chicks, and work on this subject is quoted and discussed, as well as various experimental investigations of the different ways of applying electrical heat to brooders, &c. The possibilities of applying electrical power to horticulture and to fruit production are each the subject of main sections of the report; but perhaps the most interesting applications appear in a section devoted to special applications, which includes crop drying, electro-culture, beehive heating, electric fences, and so on. A bibliography of 234 references is included.

BOOKS RECEIVED

Marryat-Scott Lift Handbook. London: Marryat and Scott, Ltd., 75, Clerkenwell Road, E.C.1. Price 10s. 6d. net.

Electrical Contacts. By G. Windred. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 16s. net.

South African Mining Year Book, 1940–41. London: Argus South African Newspapers, Ltd., 85, Fleet Street, E.C.4. Price £1 3s.

Mechanical Engineering. By W. H. Atherton. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2. Price 4s. net.

Gears and Gear Cutting. By F. J. Camm. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 5s. net.

Design of Electrical Apparatus. By J. H. Kuhlmann. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 30s. net.

The High-speed Compression-Ignition Engine. By C. B. Dicksee. London: Blackie and Son, Ltd., 50, Old Bailey, E.C.4. Price 16s. net.

Tutorial Algebra. Vol. I: Intermediate Course. By W. G. Briggs and G. H. Bryan. Revised by G. Walker. London: University Tutorial Press, Ltd., Clifton House, Euston Road, N.W.1. Price 7s. 6d. net.

THE PORT OF HAMBURG

(For description see page 359)

REIHERSTIEG SHIPYARD AND ENGINE WORKS

VIEW IN SANDTOR HARBOUR BASIN

KIRCHENPAUER QUAY

KAISERHOFT WITH TIME-BALL AND GRANARY

HAMBURG MUNICIPAL GAS WORKS

VIEW IN KAISER-WILHELM HARBOUR

The Engineer

DECEMBER 6, 1940

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MANNERS AS A BUSINESS ASSET

AN article in a recent issue of *The Economist* gives rise to several reflections which seem to have escaped the author. Despite a leftward inclination, our esteemed contemporary usually keeps its eyes right and endeavours to be as strictly logical and unbiased as a paper with its title should be. In this case, however, it appears to have allowed a modicum of prejudice to affect its judgment and to have failed to pursue its arguments to their natural limits. The article is entitled "The Supply of Brains" and is virtually an attack on the public school system which distinguishes this country from all others. It is not our purpose to discuss the essay as a whole, but rather to remind all those who are opposed to public schools that certain of the qualities that those schools engender are not a negligible asset in the affairs of the world. If we may venture to say so, it is because "the poor boys' schools," as *The Economist* calls them, neglect or even condemn these qualities that the boys are handicapped in after life.

We must quote one or two sentences to give substance for our submissions to bite upon. "Any poor boy who has climbed up the educational ladder has been made very aware by the time he reaches the top that, though he may be able to write examination papers as well as anyone, there are many other equally important things — accent, turns of speech, habits of dress—in which he has not been educated. . . . The public schools turn out perhaps 10,000 boys a year; from this tiny fraction—about 2 per cent.—of each year's graduates to life we select the great majority of those who are to be given an easy road to the top. The selection is clearly not one of merit." And again, "there is hardly a single one of the avenues to a high income or a position of honour in the community where it is not a signal advantage to possess the badges of correctness." Finally, "The social barriers will be broken down, not when a few poor boys go to the rich boys' schools, but when a lot of rich boys go to the poor boys' schools." In the first of these quotations it is admitted that certain qualities assumed to be given by the public schools are of equal merit with the ability to write examination papers, and in the second the value of "the badges of correctness" is recognised, yet the illogical conclusion is reached in the third that more boys should be sent to schools where they will not acquire these qualities and the badges of correctness. From this we must conclude that our contemporary has in fact no use for what it calls "correctness," which it regards as a middle-class bourgeois failing and that it would give no marks in assessing merit to those qualities like good manners, good accent, and so on, which do much to smooth the path of life and of business. Let us say at once that we are as much opposed as anyone to fictitious good manners; far rather would we have the natural and inherent good manners which are so frequently found amongst the poorer classes of society. But the advantage of the public school is that it so inculcates these refinements that they become second nature. Our contemporary appears to condemn the successful business man who, having himself risen from the ranks, sends his sons to a public school. But surely if "the equally important things" with the power to pass examinations are to be acquired at a public school then the father takes the right course. Is it possible that *The Economist* does not really believe in the importance of manners—we use the word comprehensively—but inclines rather to the principles which seem to be gaining ground in municipal schools that lack of courtesy is a badge of independence? If it does so, we venture to say that it seriously underrates the business value of good manners. Let us put this problem. Two boys of equal scholastic proficiency apply for a job. One is gauche and lacking in manners; the other speaks well and is courteous. Which of the two is the more likely to get the job? There can be no doubt about the answer. Let us go a step further. We will suppose that one of the boys is better than the other at his work, but is ill-mannerly. The employer has then to decide whether the good manners of the other boy will be a greater asset than the other qualities, which, in the eyes of our contemporary, constitute "merit." Clearly the lack of good manners is a handicap to the first boy; did he combine them with his other merits his selection would not be in doubt. The fact is that in business good manners are an asset. If they are not learnt at school they have to be acquired in later life by those whose dealings lie with all sorts and conditions of men.

In the profession and industries of engineering social rank does not count at all. In the past men have risen from the ranks to the highest positions, and we have no doubt that they will do so in the future. No one ever asks if they were at a public school or not. On the councils of our two leading institutions nearly two-thirds of the members were educated privately or in "poor boys'" schools. In the realms of science the same thing holds. The method of election to the greatest honour in this realm may have peculiar features, but we are sure that the Fellows of the Royal Society never ask whether a candidate has been to a public school. Pure merit counts in all these cases, but we should be just as astonished to find a member of council of the institutions lacking in good manners as we should be to find an F.R.S. so hampered. "Correctness" has not made them—as our contemporary might think—but it has proved an asset which has helped them forward in their careers. If the "public school habit" encourages this asset, surely it should be praised rather than condemned. We should not aim, as *The Economist* puts it, at sending a "lot of rich boys to the poor boys' schools," but at sending a lot of poor boys to the rich boys' school or enabling them in some other way to secure those qualities which make the intercourse between men pleasant and agreeable.

Steam Turbine Efficiency and the Reynolds Number

IT is almost inevitable that the thoughts of a student on any subject will be largely dominated by the way in which it was first presented to him. Unless he has to make use of the idea underlying the illustration by which it was conveyed, it may well be that the latter remains for him the only embodiment of the principle he is supposed to understand. For a generation or more the famous "Reynolds number" has been introduced to students by a demonstration of the sudden change from steady to turbulent flow when the number was exceeded, and many a one must have remained satisfied to regard it merely as a criterion of turbulence, enabling him to decide whether the resistance to flow should vary directly with the velocity, or be more or less proportional to the square of the velocity. The next step is to realise that a given Reynolds number in the turbulent range is associated with its own particular form or pattern of turbulence. That this must be so will be evident from a consideration of the forces which determine what form the turbulence shall take. The only forces which are acting upon any particle of the turbulent fluid are those due respectively to its own inertia and viscosity. If the ratio between these forces is kept constant, fluids must always behave in the same way so far as turbulence is concerned, whatever their nature or the scale of the experiment. Now, the Reynolds number is really nothing more than the ratio between the forces mentioned. Hence, by keeping to any given Reynolds number we can ensure a geometrically similar configuration of flow around or through geometrically similar models, and thus obtain the results we need from small-scale experiments carried out with easily controllable fluids.

This fact has been the basis of practically all the experimental work in hydrodynamics and aerodynamics during recent years. That it should have also found application in the field of the steam turbine is not surprising. The elements of a turbine, whether nozzles or blading, are after all merely closed channels containing the flow of steam, and any element of similar form traversed by any fluid with the same Reynolds number will behave in the same way as the actual turbine element. The manner in which turbine nozzles and blades do behave under experimental conditions formed the subject of a paper read recently by Mr. F. Dollin before the North-Eastern Branch of the Institution of Mechanical Engineers. The investigation was carried out by means of a specially sensitive nozzle testing apparatus designed and constructed by Messrs. C. A. Parsons and Co. to supplement the information gained from their actual testing turbines. The nozzle tester is operated with air for convenience, and although it is not practicable to work with such high Reynolds numbers as are met with in turbine practice, this leads to no appreciable error and in any case the results are strictly comparable amongst themselves. One of the facts confirmed by the tests is that the greater the pressure drop across any particular group of nozzle blades—and consequently the greater the velocity of the steam through them—the higher their efficiency becomes. This, as Mr. Dollin points out, is explainable by the nature of the flow. The continuously diminishing cross sectional area of the passage from inlet to outlet edge is a favourable condition for the suppression of eddies, so that such losses as do occur are largely due to the viscous drag on the sides of the passage. Now, since the viscous losses only increase directly as the velocity, their relative importance has the effect of causing the total losses to increase less rapidly than the square of the velocity, and therefore not so fast as the increase in the kinetic energy of the jet. The reason for the higher efficiency with the greater velocity of the working fluid thus becomes intelligible. It is quite simple to plot a curve showing the relationship of the efficiency to the steam speed, but such a curve will only hold good for blades of the particular width experimented with. The effect of width can, however, be eliminated by

plotting the efficiency, not against the steam speed, but against the Reynolds number. If this is done it will be found that the efficiencies of geometrically similar blades all fall on the same curve, which is therefore a characteristic of the form of the blades and independent of their actual dimensions. Mr. Dollin's method thus provides a means of correlating blade form with efficiency, and the only theoretical objection that can be urged against it appears to be that for perfect geometrical similarity of the passages the blade lengths must always bear the same proportion to their other dimensions. Other things being equal, a short blade will always be less efficient than a long one of the same profile because of the relatively greater importance of the end losses. The author of the paper meets this difficulty by basing the Reynolds number, not on any particular dimension of the blade itself, but on the hydraulic mean depth of the passage at the throat. This dimension is as good as any other when the passages are geometrically similar, but when they are not, as in the case of blade groups of varying height, it has the advantage of making an allowance for end effects which is inversely proportional to the blade heights, and so of putting all blade lengths on a more or less equal footing.

Apart from the usefulness of the Reynolds number in enabling the results of blading and nozzle experiments to be co-ordinated, the fact that the efficiency increased with the Reynolds number throws a useful light on many things in connection with turbine work. Water turbines for example, are in general more efficient than steam turbines, the reason being that they can operate with higher Reynolds numbers on account of the greater density of the working fluid. Efficiencies, however, of over 90 per cent. are stated by Mr. Dollin to have been obtained with steam turbines under the most favourable conditions, namely, high Reynolds numbers, small clearance losses and no wetness losses. He refers also to the extremely high efficiencies often attributed to the high-pressure unit of a two-cylinder turbine, as deduced from pressure and temperature measurements at the inlet and exhaust. The performances are frequently so good that the figures are viewed with suspicion, but, as he says, they may not be far wrong because of the magnitude of the Reynolds numbers in that part of the turbine. The value of the conception of the Reynolds number in connection with turbine work is, however, by no means confined to the explanation or correlation of facts. It serves also to indicate certain lines along which higher efficiency may be sought. Two of the factors on which the magnitude of a Reynolds number depends are the density and velocity of the working fluid. Other things being equal, the greater the density the higher the number, and consequently the greater the efficiency. It follows, therefore, that high-pressure steam is more favourable to efficiency than low-pressure steam, provided, of course, that the gain is not neutralised by extra leakage losses. A high steam velocity is also favourable, and since this implies a correspondingly high blade velocity, the highest possible speed of rotation is manifestly desirable, not only from the mechanical, but also from the aerodynamic point of view. These conclusions are both drawn by Mr. Dollin, who notes that they justify the present tendency towards higher pressures and higher speeds, although both these advances are justifiable on quite other grounds.

Tacoma Narrows Bridge

IN our issue of November 15th we described the Tacoma Narrows bridge, news of the failure of which had just reached this country. The following article and accompanying remarkable engravings are reprinted from *Engineering News-Record*.

Wind wrecked the 2800ft. main span of the Tacoma Narrow suspension bridge shortly before noon, Thursday, November 7th. Almost the entire suspended structure between the towers was ripped away and fell into the waters below, but the 1100ft. side spans remained intact. Cables and towers survived and held up the weight of the side spans, though the latter sagged about 30ft. as the towers, which are fixed at the base by steel anchors deeply embedded in the concrete piers, were bent back sharply by the unbalanced pull of the side span cables.

Fortunately there was no loss of life, as only a few persons were on the bridge. Traffic had been limited or shut off some time before because of the excessive and dangerous motion of the bridge. Among those on the span at the time was Professor F. B. Farquharson, of the University of Washington (Seattle), who had been conducting extended experiments on a model of the bridge with a view to controlling its oscillation. At the time of the collapse he was on the main span taking motion pictures of the abnormal waving and twisting.

Wind Conditions Not Abnormal

A wind reported as 42 m.p.h. was blowing on the morning of the accident. Higher winds had been experienced previously without damage, but this wind caused a vertical wave motion that developed a lag or phase difference between opposite sides of the bridge, giving the deck a cumulative rocking or side-to-side rolling motion.

Failure appeared to begin at mid-span with buckling of the stiffening girders, although lateral bracing may have gone first. Suspenders snapped and their ends jerked high in the air above the main cables, while sections of the floor system several hundred feet in length fell out successively, breaking up the roadway toward the towers until only stubs remained.

Efforts to Check Wave Motion

Tie-down cables that had been put in the side spans to damp out vertical wave motion previously observed on the bridge are credited with having prevented the violent waves in the main span from being transmitted to the side spans and perhaps doing greater damage to the towers. However, with the load removed from the main spans by the fall of the floor, the side spans sagged 30ft., making the check reins inoperative and permitting a movement which buckled the stiffening girders and deformed the steel in the floor system.

Under the unbalanced loading the towers were bent back 12ft. shoreward (about twice the designed maximum) until unloading of the side spans began, when the tower deflection gradually decreased. Outward evidences of tower damage are buckled plates and angles, especially near the piers where plate thicknesses are ½in. to ⅝in. An inspector reports that the cables show no evidence of movement in the saddles in the course of the violent bouncing. The piers are believed to be undamaged.

Tacoma Narrows bridge, third longest suspension span in existence (Golden Gate, 4200ft.; George Washington, 3500ft.; Tacoma Narrows, 2800ft.) was built between October, 1938, and July, 1940, and was opened to traffic in July. It was by far the most slender suspension bridge ever built, both laterally and vertically, the width of the roadway and spacing of cables being only 39ft. (span ratio 1 : 72), and the depth of the stiffening girders 8ft. (span ratio 1 : 350).

In general conception it followed the model set by the Whitestone bridge (span 2300ft.), but was longer in span and much narrower. To suit the expected traffic it was built for only two traffic lanes against six on Whitestone and Golden Gate and an ultimate of twelve on the George Washington bridge.

Wave Motion Studied

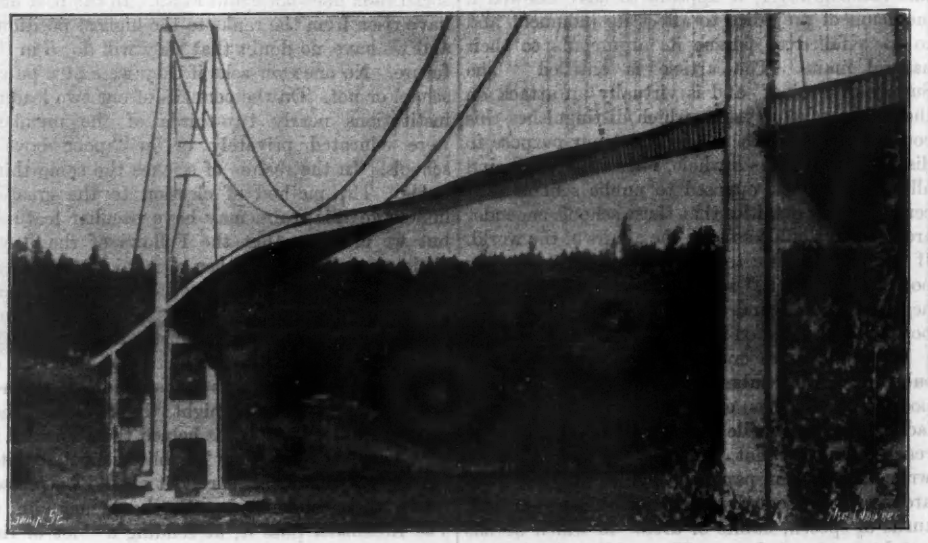
The destructive wave movements that wrecked the bridge were the sequel to a history of disturbing oscillation that had been under observation and study since the bridge was built. Similar but much smaller oscillation occurs on the Whitestone bridge, but while there it amounts to only a few inches, the vertical waves in the Tacoma bridge were very much greater, having reached as much as 50in. amplitude.

Various means were tried to check the movement, and elaborate model experiments were conducted, those for Whitestone by Professor E. K. Timby at Princeton University and those for Tacoma Narrows by Professor F. B. Farquharson at the University of Washington. The Tacoma Narrows model, 54ft. long, is a precise scale representation of the bridge in 1 : 100 ratio and is fitted with a series of electro-magnets to apply horizontal and vertical forces simulating the effect of wind pressures. It was found that the behaviour of the actual bridge could be duplicated with great accuracy, and various corrective arrangements and devices were tried out.

SIDE SPAN AFTER COLLAPSE OF BRIDGE

Tie Ropes Reduced Movement

In the Whitestone bridge short inclined rope ties were placed between midpoints of the main cables and the top flanges of the stiffening girders to hold the bridge deck from moving longitudinally with respect to the cables, and friction brakes were placed at the connection of bridge deck and towers to damp any longitudinal movement; these provisions reduced the vertical oscillation materially.

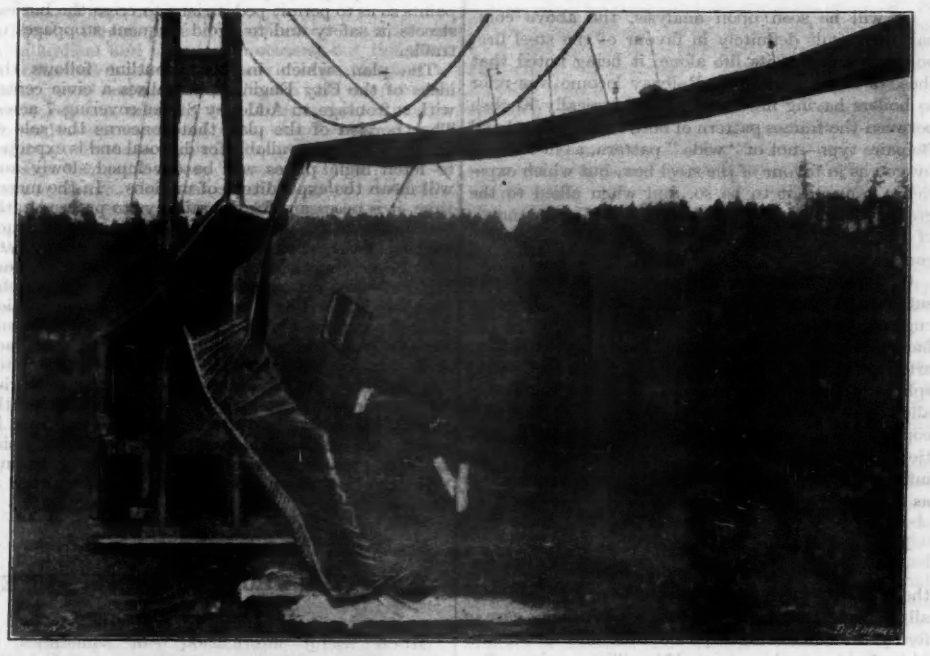


WAVING MOTION OF BRIDGE

At Tacoma Narrows one control method applied, after proving effective on the model, was to tie down a point in each side span to the ground below. Such tie was provided on the bridge in the form of 1 3/16 in. cables extending from the deck of the side spans to 50-yard concrete anchors on the ground below, at points 300ft. out from the anchorages. These ropes broke three or four weeks ago during a moderate blow. Diagonal ties from the tower tops to the stiffening girders were considered but not tried.

STREAMLINING FOUND EFFECTIVE

Recent work with the big Tacoma Narrows bridge model and with smaller models exposed in a wind tunnel was directed to determining whether the form of the stiffening member contributed to the oscillation trouble, and to trying out the effect of various shielding or streamlining fascia arrangements along the sides of the girders. Proper streamlining almost completely suppressed the disturbing wind effects, it was found. Application of these experimental findings to the bridge had not been possible at the time of the accident.



COLLAPSE OF THE TACOMA BRIDGE

Prior to November 7th such vertical waves as had occurred never got out of step on opposite sides and no damage was done, although at times smooth uniform waves with as much as 50in. amplitude were observed.

Ten different wave periods had been observed on a 1 : 100 model in the University of Washington laboratory, and on the bridge itself, observed perhaps more frequently than others, was the twelve-second period, the same as the period of the towers.

In the various waves it had been noted that the mid-span was subjected to the least vertical movement and, presumably, to the maximum of flexure. It was here, most witnesses say, that the first structural failure occurred.

Supporting the theory that the stiffening girders were the first to fail is a picture that shows a decided disalignment of these girders at mid-span (possibly a kink or a shear rupture) at a time when the concrete roadway can be seen to be still intact. Another picture, taken soon after the first concrete fell out, shows a pair of diagonals of the lateral system broken loose and hanging below the floor system.

EYEWITNESS ACCOUNT

F. B. Farquharson, Associate Professor of Civil Engineering, University of Washington, who directed the model studies and is familiar with the traits of the bridge, was on it as the destructive wave motion built up. He reports that the deck tilted from side to side more than 45 deg., that the edges of the deck had an up-and-down movement of 28ft. and that the acceleration in the movement of the deck at times exceeded that of gravity.

Conditions observed in the collapse support the theory, reached about a month ago, that the cause of the vertical waves was aerodynamic instability of the floor system. A 1 : 20 model of a section of the floor system, tested in the wind tunnel at the University of Washington, was found to have unstable characteristics that fully account for the wave movement. This test was followed by studies looking to remedial measures. These had been developed and a contract for their installation on the bridge was under negotiation when the collapse occurred.

The remedy is extremely simple, consisting of a deflector vane that changes aerodynamic characteristics in such a way as to prevent the continual reversal of vertical components of wind forces. Unchecked, these forces build up cumulative wave motion, which, after a considerable weight of bridge deck is involved, accumulate destructive energy.

Prospects are for immediate reconstruction of the bridge if the condition of towers and cables justifies. Removal of the floor of the side spans is now in progress, and final decision on whether the cables and towers will have to be dismantled must await completion of this work and inspection after the unloading. The bridge was insured, so that there will be small, if any, loss to the State and the Federal financing authorities.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

DIMENSIONLESS CHARACTERISTICS OF TURBINES AND PUMPS

SIR,—During the past two years your contributors, Mr. J. J. Jennings and Mr. G. G. McDonald, have made a number of exceedingly useful suggestions for presenting in non-dimensional form the behaviour of turbines and centrifugal pumps. As this material will undoubtedly be used in future discussions on the subject, it now seems desirable to try to standardise the terminology involved. I therefore offer for consideration the following views :—

Non-dimensional Specific Speed.—This is the title hitherto used for the forms :—

n_s = non-dimensional specific speed of turbine

$$= \frac{n\sqrt{\frac{p}{P}}}{(g\,h)^{\frac{5}{4}}}$$

n_s = non-dimensional specific speed of pump

$$= \frac{n\sqrt{q}}{(g\,h)^{\frac{3}{4}}}.$$

Now, since these quantities are pure numbers it is not strictly legitimate to entitle them rotational speeds, which actually have the dimension 1/T. Would it not thus be preferable to use instead the term specific number ? By so doing we eliminate the possibility of confusion with the usual expressions for specific speed

$$N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}} \text{ (turbine)}; \quad N_s = C.\ \frac{N\sqrt{Q}}{H^{\frac{3}{4}}} \text{ (pump)},$$

and we are enabled to distinguish between the two complementary physical conceptions that are embodied in the terms.

The specific speed N_s of a given runner or impeller, in spite of its curious dimensions, can conveniently be regarded as an actual speed in revolutions per minute ; it is the speed of a wheel geometrically similar to the given wheel, of such a diameter that, when working in equivalent conditions under unit head, it develops unit power.

On the other hand, the specific number n_s, although linked to specific speed by a conversion factor, which is invariable for a selected system of units, is itself free from the restraint of dimensional units. We are thus left free to concentrate on shape as opposed to size, and we can regard the specific number as a concise description of the proportions of the wheel and its casing, taking into account blade angles, ratio of width to diameter, and ratio of inner to outer diameter.

Non-dimensional Expression $\frac{q}{n\,d^3}$.—Designations hitherto used for this expression are "specific flow" and "output coefficient," while conditions such that the value of the expression remains constant have been described as "synchronous flow conditions." Admittedly it has such a comprehensive meaning that it is going to be difficult to find a sufficiently descriptive portmanteau word or phrase. The statement that two geometrically similar pumps have identical values of $q/n\,d^3$ implies that the pumps are running at similar points on their characteristics, and that, apart from the varying effects of friction, they are working at the same efficiency. Furthermore, the numerical value of $q/n\,d^3$, when applied to the proper units, expresses the discharge of a pump geometrically similar to the one from which the figures were obtained, but having an impeller of unit diameter running at unit speed.

Of the various terms that suggest themselves, specific may be ruled out because it has already been allocated for a distinctive purpose. Besides, a specific wheel is one developing unit power, whereas we now have in mind a wheel of unit diameter. It is hard to dissociate the word coefficient as used in hydraulics from an experimental or empirical relationship, such as the coefficient of a weir or orifice. Number should be reserved for fundamental relationships, *e.g.*, Reynolds number, Froude number, specific number. But the bond between $q/n\,d^3$ and the pump characteristic is one that we wish to insist upon, and I therefore make the provisional proposal that the expression $\frac{q}{n\,d^3}$ be known as the characteristic discharge ratio or as the characteristic output ratio.

Non-dimensional Expression $\frac{g\,h}{n^2\,d^2}$.—If values of this expression, as derived from all pumps belonging to the same geometrically similar family, are plotted against the corresponding values of the characteristic discharge ratio, the resulting points will lie on or near a single characteristic curve. Also, in just the same way that $q/n\,d^3$ expresses the discharge of a "unit pump," so the expression $\frac{h}{n^2\,d^2}$ gives the equivalent head generated by the "unit pump."

It seems logical, therefore, to say that the quantity denoted by $\frac{g\,h}{n^2\,d^2}$ is the characteristic head ratio.

Of course, I am well aware that technicians, no less than ordinary folk, are apt to resist compulsion in matters of terminology. Certainly I have not the least desire to be authoritative. But, remembering that some recently introduced units, such as "poise," "stoke" and "slug," are convenient and free from ambiguity, while "cusec" is faulty, it does seem desirable to agree upon descriptive terms before less acceptable ones get into circulation.

HERBERT ADDISON,
Professor of Hydraulics.

Egyptian University,
Giza, Egypt,
October 12th.

TOWN'S GAS FUEL FOR PETROL MOTORS

SIR,—In reply to "ENQUIRER'S" letter which appeared in your journal of November 15th, my first duty must be to disclaim any expert knowledge of the gas engine as such ; and secondly, to apologise for the delay in replying to his letter of October 25th, to which my attention has only just been drawn.

I would like to make it clear that my paper to the Institute of Fuel dealt only with the simple conversion of petrol engines to operate on towns' gas, with the minimum interference to operation on petrol.

As was pointed out in the paper, the limitations imposed by this minimum interference with petrol performance operate seriously against optimum performance on gas. The question of increasing the compression ratio was not dealt with in the paper, since for practical reasons this cannot be done when a vehicle is required to run on petrol or gas without engine modification. It was further pointed out that with the high-speed internal combustion engine it is possible to obtain higher thermal efficiencies by working with weak mixtures and large ignition advances, but that this result can only be obtained at the expense of power output, which could not be afforded in the simple conversion.

With reference to this point, I would like to draw "Enquirer's" attention to the curves for petrol and towns' gas given in Dr. Pye's book "The Internal Combustion Engine," Vol. 1 (1937), page 175, which clearly show the rise in thermal efficiency and fall in power output with weakening of mixture below 120 per cent. of correct.

The question therefore resolves itself into the most economic design and operating conditions for gas engines, a subject on which I am not qualified to give an opinion. It is obvious, however, that the data on fuel consumption on a converted high-speed internal combustion petrol engine not designed to run on a gaseous fuel cannot be compared with the figures obtained for a gas engine operating under optimum conditions.

ERIC A. C. CHAMBERLAIN.

London, November 29th.

STEEL *V.* COPPER FIRE-BOXES

SIR,—Your leader on the above in THE ENGINEER of September 13th last appears to the writer an outstanding instance of a general judgment founded upon particular cases, and these latter—in this instance—constituting a remarkably inadequate basis of data and experience.

With one of the reasons stated in favour of the home railways continuing to use the copper fire-box, viz., that steel of the required characteristics is at present less easy to obtain than copper, I am not in a position to dissent, although it appears strange, to say the least, and its validity may be changed by circumstances at any time. Your remark that "the development of a satisfactory steel box for British locomotives could only be reached by a long course of experiments, &c. &c.," would, however, appear to indicate that as far as British locomotives design and British locomotive engineers are concerned, an appreciation of the fact that perfectly successful performance of steel fire-boxes exists in other countries and that they could be "trained" to perform in England, is still postponed. This is, of course, not really the case and British locomotive engineers in most other parts of the world know the advantages of steel fire-boxes.

The main thread in your comment is that steel is an inferior substitute for copper as a fire-box material and that it is employed for reasons of cheapness. Whilst it certainly is cheaper, *the* reason it is used by those who do use it is precisely because it gives less trouble than copper for extremely hard working conditions, particularly including "working up a bank and then down," beyond any notion of this trying process generally visualised in England; in other words, because a copper box will not stand up to the same punishment that a steel box will; and further, that the use of steel was adopted to reduce the abnormal cost of repairs to copper boxes under such conditions.

As you state that your opinion is based on the results of some steel fire-boxes tried in England during the latter part of the last war, I would remark that these cases appear to have represented only some 1½ per cent. of the locomotives of the lines upon which the trials were made; that many of such fire-boxes had sharp radii in the corners; that doubts existed about the actual quality of the material ("shelling of fire-box plates to ¼in. deep"—I have only seen two shelled spots in steel fire-boxes during the past eighteen years—no wonder there were doubts!), &c. &c. I will not, however, waste space on further reference to the catalogue of various troubles experienced some twenty-five years ago with those fire-boxes apparently of unsuitable design and/or unsuitably operated and maintained—except to instance that leaking tubes always occur in steel tube plates when the proper method of applying steel tubes to such is not used, whilst anyone connecting a steel fire-box to a steel shell plate by means of copper stays is patently asking for trouble. It must also be remembered that the "state of the art" of using steel fire-boxes has not remained stationary during the past twenty-five years.

As reference is made in your leader to mileages obtained from steel fire-boxes (some appearing so incredible as to suggest error), instancing such a particularly low "best attained" steel fire-box life of 154,589 miles cited by you as if it were a to-be-expected concomitant of the use of steel fire-boxes, I give you the following figures:—

Average Life of Fire-boxes

Railway.	Fuel.	Material.	Mileage.
Lancashire and Yorkshire	Coal	Copper ...	420,000
Lancashire and Yorkshire	Coal	Steel ...	100,258
Caledonian and Highland	Coal	Copper ...	304,214
Caledonian and Highland	Coal	Steel ...	142,341
Central Uruguay	Coal	Copper ...	490,743
Central Uruguay	Half life coal, half oil fuel	Copper ...	701,854
Central Uruguay	Half life coal, half oil fuel	Steel ...	763,296
Central Uruguay	Calculated proportionally as if on coal	Steel ...	533,650

As will be seen upon analysis, the above comparisons result definitely in favour of the steel fire-box in respect to its life alone, it being noted that those of Central Uruguay Railway locomotives refer to boilers having fire-box shells of typically English between-the-frames pattern of both round-topped and Belpaire type—not of "wide" pattern, as mentioned by you as in favour of the steel box, but which experience proves not to be so, and when allied to the greater dependability and lesser cost of maintenance of the steel box and tubes the answer is certainly conclusive.

Of course, it is necessary to know the ropes from sufficiently extended experience in this as in other engineering matters before success is attained; but facts are facts, and the picture drawn in your leading article, although it may be in accord with the limited sphere of action upon which it is based, cannot be allowed to stand as a general judgment upon steel *v.* copper fire-boxes without comment upon its limitations, as otherwise it appears likely to incorrectly influence those not knowing the true state of the case as a whole.

P. C. DEWHURST,
M. Inst. C.E., M.I. Mech. E.

Montevideo, October, 1940.

P.S.—It may be of interest to mention that upon the C.U. Railway cases of a tube actually leaking at all in service, of which there has been only one case in five years (this being a pitted tube and not a tube plate leak), equals one per 17½ million engine miles, and no work is done upon tubes between general repairs at 120,000 miles apart.

A Greater Cape Town

DURING 1940, after four years' intensive work the scheme for remodelling and large extension of the New Basin at the Cape Town harbour will be completed. The basin, which will have cost in all £6,000,000, will have nine berths capable of accommodating the largest vessels afloat and with a depth of water of fully 40ft., while there is sufficient further space for another six berths and a site is prepared for a dry dock 1200ft. long. Some of the berths are already in use, and it is fortunate that the work was put in hand when it was; eighteen months later and there would have been to-day such congestion and waiting for berths as would have delayed the transport of Allied troops and munitions and supplies to the various theatres of the war.

The scheme included the reclamation from the bay of 365 acres of land. Of this about 234 acres will adjoin the area of the city bounded by Wale Street, Buitengracht Street, Buitenkant Street, Dock Road, and the Marine Drive. It will represent an addition to the area of Cape Town greater than the existing central business and commercial part of the city, as defined above, and usually described as the metropolitan area, and of which the new area will form part.

Experts commissioned by the Government have recently furnished a report containing a scheme for the lay-out of the area which is being reclaimed. This area of virgin land immediately in front of the city with the wonderful background provided by Table Mountain will give an opportunity almost unique in history for wise and careful planning. It is the general opinion that the experts have given consideration to the natural amenities of the city as a whole, and also ensured for the future that freedom of circulation which is demanded by modern transport conditions, and at the same time have preserved the beauty and dignity of the city. The approach to the town from the sea has been designed on a monumental scale worthy of the term applied to Cape Town—the Gateway of South Africa. The lay-out of the street, the heights of buildings, and all other matters have been adjusted by the experts to permit of the construction of this approach, which will be in keeping with the natural beauty of Cape Town. The plan makes provision for the new main and suburban passenger station, and, in addition, there will be a new marine station at the dock where passengers arriving by sea will disembark in most comfortable circumstances. They will have no contact whatever with the dockside quays. Provision is also made for a simple and direct system of main roads of adequate width for traffic entering the city from the suburbs, from the national and provincial road systems, and from the harbour and airport. There will be considerable additions to the commercial centre along the Adderley Street line. As one moves south the civic centre and central park is reached and from there one gradually passes into the area of markets and warehouses adjoining the Woodstock end of the new area. The whole of the dock railway service will pass along the dock front so that only the main and suburban lines will come into the new station. The new main station, which will be just below the existing one, will face on to Adderley Street, but be set well back, and there will be ample parking facilities in its neighbourhood. It is also proposed to construct subways at some points so as to permit pedestrians to cross the busiest streets in safety and to avoid frequent stoppages of traffic.

The plan, which in broad outline follows the ideas of the City Engineer, visualises a civic centre with a frontage to Adderley Street covering 7 acres. That portion of the plan that concerns the sale of land that will be available for disposal and is expected to fetch high prices will be developed slowly and will mean the expenditure of millions. In the meantime, it is necessary for the railways to proceed without delay with a good deal of their new work, such as the construction of a new railway goods yard and the new marine railway station. Taking advantage of the opportunity for "wise and careful planning," the City Council is now in negotiation with the purchasers of the present Post Office site for the proposed new building to be thrown back some 20ft., so that the wide boulevard contemplated for the lower end of Adderley Street may be carried for practically three-quarters of the length of the street. The Standard Bank, too, will in time be rebuilt, and the surrendering of that portion occupied by the present portico and enclosed by railings will enable the extended width to be carried to Darling Street.

UNUSUAL METHODS OF TEMPERATURE MEASUREMENT*

MUCH useful information can sometimes be obtained by rather fantastic methods. The fusible plug of the boiler has found a new application in the measurement of piston temperatures. Tiny plugs of various metal alloys melting at known temperatures, and in size about equal to short lengths of pencil lead, have been inserted in small holes drilled into the piston metal, and there secured by light pening. After running, certain of these plugs will have melted or lost the sharpness of their edges, while others will be unaltered, and these facts are noted. The holes may then be cleared or new ones made, and a modified group of plugs inserted and tested. "Intelligent guess work" soon enables suitable ranges of plugs to be selected and the temperatures may be mapped with reasonable accuracy.

One investigator, like a famous matron during the reign of King Alfred, has judged temperature by the presence of a state of char. Felt was inserted behind piston rings, and their temperatures were judged by the presence or absence of the deterioration produced by heat. No doubt a piece of teacake could be used with like success, but the writer has not investigated the matter, and, to save getting his ears boxed, prefers more "scientific" methods.

At particular temperatures certain light alloy piston materials undergo structural alterations which can be revealed by etching, but the critical temperature is both unique and high, and the piston is rendered useless. An improvement on this method depends on the irreversible colour changes affected at specific temperatures by certain thermo-paints. The piston or other part is painted in suitable patterns with a range of paints exhibiting their colour changes at different temperatures, the boundaries of the coloured areas showing, after heating, the change point isotherms.

POROSITY OF TIN-PLATE.—A new tinning machine, designed by the International Tin Research and Development Council's research organisation at Greenford (now known as the Tin Research Institute), has already demonstrated that significant reductions in the porosity of tin-plate are possible. Tin-plate, with a coating of only 1 lb. of tin per base-box, for example, may have as many as 300 pores on every square inch of surface, but heavily coated plates have relatively few pores. A non-uniform coating therefore tends to have excessive porosity in places where the coating is thin. The features of the machine are the provision of a perfectly smooth drive, and the use of a pair of non-tinnable rollers, which could be incorporated in existing tinning machines without great expense.

* From The Measurement of Temperature in Machinery in Motion, by H. Wright Baker. Manchester Association of Engineers, November 9th, 1940.

Transformers for Electric Furnaces

EASY and convenient control of the generation and transfer of heat and also of the physical changes and chemical reactions in the furnace charge are among the many advantages which the electric furnace possesses over other forms of industrial heating. The two types of electric furnace in most general use are the "arc furnace" and the "resistance furnace," and in most cases the provision of transformer equipment is necessary in order to reduce the available supply voltage to a suitable value and to permit of that value being varied between certain limits. The successful operation of the furnace depends on the provision in the transformer of certain special characteristics combined with the robust construction necessary to withstand the very severe duty that is the normal function of such equipment.

The arc furnace is used in connection with various metallurgical and chemical processes, but this form of industrial heating has its widest application in melting steel and maintaining it at a high temperature during refining, alloying, &c. The graphite or carbon electrodes are contained in a chamber lined with refractory material, the heat required being generated by arcs formed between these electrodes and the furnace charge. In most cases the charge is cold at the commencement of the cycle of operations and requires a maximum energy input at the higher values of voltage available to break it down into the molten condition. During this portion of the duty cycle, lasting from 1½ to 2 hours, frequent and heavy overload conditions, amounting at times to short circuits

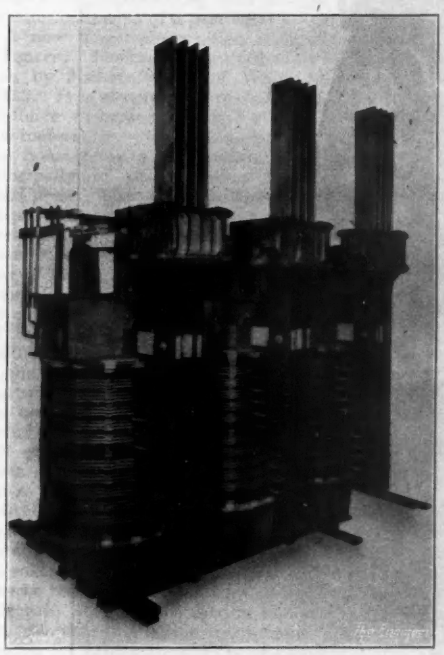


FIG. 1—ARC FURNACE TRANSFORMER WITH CONCENTRIC WINDINGS

across the transformer secondary windings, are encountered. As the cycle proceeds the heat receptivity of the charge and the energy input required decline and refining, if carried out, necessitates a comparatively small input at reduced voltage for 4 to 7½ hours, depending on the particular product of the furnace.

In view of the severe operating conditions during the melting period, high reactance may have to be incorporated in the furnace circuit, and this may be as high as 50 per cent. in order to limit peaks on the supply system during the melting period. Since it may be impossible to incorporate in the transformer and its connections sufficient inherent reactance, it may be necessary to provide additional reactance in the form of a reactor mounted in the transformer tank or installed as a separate unit. This reactor is usually so connected in the furnace circuit that it can be switched out of circuit at a certain point in the duty cycle, usually at the termination of the melting period.

It is important that the operator should be able to maintain close control of the energy input, since any heat generated in excess of that which can be absorbed by the charge is reflected to the furnace lining, especially to that of the furnace roof, leading to rapid deterioration. The frequent renewal of the furnace lining is obviously expensive, and this involves not only the cost of the actual relining, but also loss of output. The control of energy to the furnace is effected by adjusting the length of the arc and by altering the voltage tappings on the transformer. Owing to the high heat contents of the furnace and the charge, momentary discontinuance of the energy supply is unimportant and therefore it is usually unnecessary to incur the expense and complication of changing the transformer tappings on load. The range of secondary voltage required is considerable, being, for example, 60 per cent. in the case of a steel melting furnace to 30 per cent. in the case of a carbide furnace. Fortunately, in most cases the power required can be reduced in proportion to the reduction in the secondary voltage, so that the higher secondary voltage values can be obtained with the primary windings of the transformer connected in delta, and by changing such connections to star the same tappings can be used to give the lower values of voltage.

Resistance furnaces are used for processes requiring a constant temperature or a slow temperature cycle (*e.g.*, heat treatment, annealing, &c.). The heat is generated by resistance units of special alloy, or in certain cases by the resistance of the charge itself. It follows that constant current is required, not constant kVA, and that in many cases only infrequent voltage adjustment is necessary. This is carried out by tapping boards or by a standard type of manually operated off-circuit tapping switch. Some types of large resistance furnace have a number of heat zones, and in such cases the heating units in each zone are separately supplied by low-voltage transformers, which are in turn supplied from a main step-down unit taking a high-voltage supply from the mains. The relative temperatures of the various zones can be adjusted by tapping links on the individual low-voltage transformers, whilst the temperature cycle of the furnace as a whole is controlled by primary tappings on the main transformer in much the same way as for arc furnaces.

Whilst furnace transformers are in general built to comply with the current British Standards Specification, it should be borne in mind that the operating conditions are very arduous and only the best mechanical construction for the windings, tap changers and terminals is admissible.

The standard core construction adopted by the British Thomson-Houston Company is suitable for furnace duty, since the whole of the core insulation complies with the requirements of British Standards Specification for Class "B" Insulation. The laminations are coated with a special "flash" enamel applied at a high temperature and, as an additional precaution, sheet asbestos is inserted at 1in. intervals when building up large cores. Core bolt insulation consists of asbestos and synthetic resin moulded on under high pressure and temperature. Vertical ventilating ducts are provided by H-section spacers welded to adjacent core plates, and horizontal ducts by slots in the laminations, these slots being situated between and in line with the core bolt holes.

Furnace transformers can be built for any primary voltage, the primary windings employing generally the same construction as for power and distribution transformers of a similar rating, while the heavy current secondary windings consist of a number of coils connected in parallel, each coil having only a few turns of large cross section made up of a large number of strands in parallel to ensure satisfactory current distribution. Either the concentric or the interleaved arrangement of windings may be adopted —see Figs. 1 and 2—and great care is taken by suitable disposition of the windings to ensure good electromagnetic balance under all operating conditions, and also to brace and anchor the conductors in order to withstand the heavy short-circuit forces inherent in furnace operation.

As stated previously, constant current output over a voltage range up to 60 per cent. is a usual requirement, and in such cases the primary winding is tapped and arranged for delta-star connections, all tappings and phase ends being brought up to off-circuit tapping and change connection equipment arranged for manual or—more usually—for remote electrical control. This equipment is always interlocked with the primary circuit breaker so that the latter must be opened before the former can be moved. It should be noted that the normal type of off-circuit tapping switch, such as is thoroughly satisfactory on power and distribution transformers, is quite unsuitable for this duty, which, on account of very infrequent operation, requires much more robust equipment. The off-circuit tap-changing equipment provided on B.T.H. furnace transformers is, in effect, "on-load" gear, specially adapted to furnace operating conditions. A type of tapping and change connection switch fitted to larger sizes of furnace transformers is illustrated in Fig. 3, this switch being suitable for supply voltages up to 33 kV. In cases where constant kVA output or when on-load tap changing is essential, it is obviously impossible to use the delta-star arrangement of primary windings, and it will be

FIG. 2—ARC FURNACE TRANSFORMER WITH INTERLEAVED WINDINGS

appreciated that this increases the physical size and cost of the transformer approximately in the ratio of the maximum to minimum secondary voltage.

For most types of arc furnace, high reactance is required to stabilise the arc, and to reduce peak loads on the supply system during the melting furnace period, and it is usual for reactors to be provided in series with the transformer primary to supplement the inherent reactance of the transformer. The amount of reactance required is governed not only by the furnace characteristics, but by the economic conditions—maximum demand charges, system voltage regulation, &c.—under which the electric supply is obtained. In practice, the total reactance required for individual installations may vary from 20 to 50 per cent. Where the delta-star arrangement of primary windings is used, the inherent transformer reactance is often sufficient when the primary windings are star connected, and provision

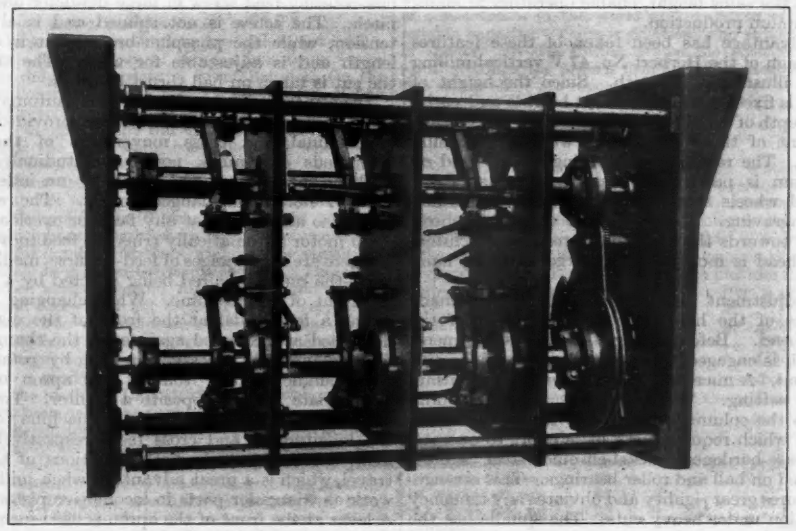


FIG. 3—OFF-CIRCUIT TAP AND CONNECTION CHANGE SWITCH

can be made for the insertion of this supplementary reactance only when the higher secondary voltages are in use—that is, during the melting period. In order to make the equipment as flexible as possible, the reactor is usually provided with tappings to give alternative values of reactance.

Secondary currents may be required up to a very large value, and where these currents exceed 2500 amperes, delta-connected secondary windings are preferable so as to obtain the minimum winding current and the maximum number of secondary turns per phase. Owing to the heavy current involved, the secondary terminals of furnace transformers almost always consist of copper bars brought out through non-magnetic inserts in the tank side or cover, and these bars are interleaved to reduce the reactive drop of stray losses in the base, the secondary interphase connections being made at a point as close to the furnace electrodes as possible. The design and lay-out of the low-voltage connections, with provision for expansion and cooling, require close study and very great care if the maximum economy in the overall costs is to be obtained, and extensive experience is probably the most valuable factor in the solution of this problem.

The selection of the beat method of cooling requires careful consideration for each individual case. For small resistance-type furnaces air-cooled dry transformers are probably the best. Although more expensive than oil-immersed units, they have lower fire hazards, and can therefore be placed close enough to the furnace to economise in secondary leads. The substitution of transformers filled with "Permitol" liquid di-electric—which is non-inflammable—for oil-filled units may be worth consideration in such cases. Oil-immersed, self-cooling units are usually employed for larger resistance furnace transformers, and for all arc furnace transformers up to about 5000 kVA, but space limitation may necessitate forced cooling at ratings lower than this value.

For units above 5000 kVA, forced oil circulation with water cooling is usually the best solution. Cooling water has to be provided for the furnace and is therefore available. For this type of cooling the B.T.H. Company employs a glandless oil pump of a special type, in which the driving motor is immersed in the oil to circulate the oil from the top of the transformer tank through a heat exchanger—in which heat is transferred to the cooling water—and back to the bottom of the transformer tank. This cooling equipment can be mounted on the transformer tank and a very compact lay-out is possible.

Furnace transformers frequently have to operate under very dirty conditions, and it is therefore advisable to avoid where possible bare high-voltage connections and to bring the primary supply through cable boxes into the tank. The use of oil conservators with magnetic oil gauges is recommended, although it should be noted that they add appreciably to the first cost of large heavy current units, because they necessitate oil-tight glands on the secondary copper bar terminals. Where conservators are provided, "Buchholz" protective devices can be fitted to give protection against internal faults. A thermometer with maximum reading pointer and alarm contacts is desirable on the larger units.

Motor-Driven Vertical Milling Machine

THE kneeless type of milling machine possesses all the convenience and ease of operation of the ordinary knee-type machine with the added advantage that for heavy work the table is supported solidly down to the foundation. The controls, also, being always at the same height, enable operators to maintain maximum production.

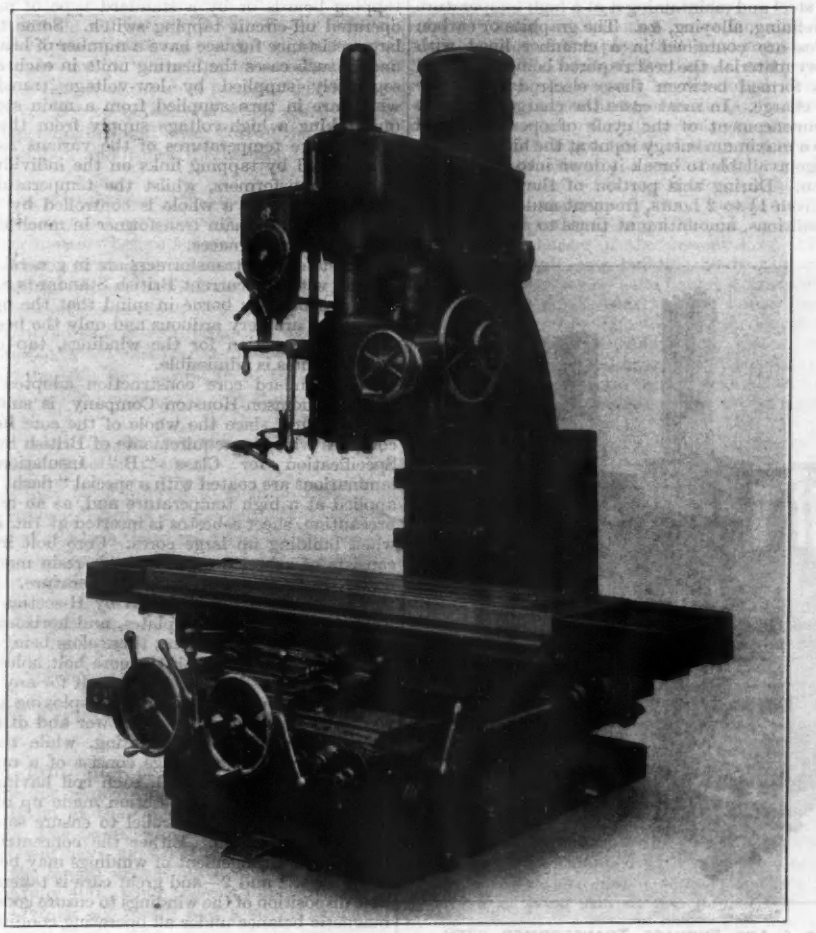
Full advantage has been taken of these features in the design of the Herbert No. 47 V vertical milling machine, illustrated herewith. Since the height of the table is fixed, work of different heights and variations in depth of cut are accommodated by the vertical adjustment of the spindle head, which is carefully balanced. The raising and lowering of the head on the column is particularly easy by means of the two hand wheels seen on the right of the column in our engraving. The smaller of the hand wheels is turned towards the operator to release the clutch, and the head is moved by the large diameter hand wheel.

Fine adjustment for putting on the cut is made by means of the hand wheel at the front of the spindle head. Before using the fine adjustment, the clutch is engaged by the hand wheel at the side of the head. A micrometer dial is provided to ensure accurate setting. When set the head is solidly locked to the column by means of the long lever at the front which requires very little effort to operate.

The case-hardened nickel-chrome steel spindle is mounted on ball and roller bearings. This arrangement ensures great rigidity and obviates any tendency to vibration under heavy cuts. The spindle has the standardised nose with non-stick taper and standard clutch drive with provision for securing cutters direct to the spindle. A draw-bolt and adapter are provided for securing arbors and cutters with No. 11 B. and S. taper shank.

The spindle head incorporates fast and slow-speed ranges, the change from one to the other being made by the hand wheel on the left of the head. Sixteen spindle speeds are provided, eight fast and eight slow, the extreme speeds being 21 and 750 r.p.m., so that all work within the capacity of the machine can be done at the most suitable speed. Rapid changes are effected by rotating a large, easily read dial until the speed required is opposite a pointer. The drive to the spindle is by a 7½ H.P. reversing vertical-flanged motor, which is controlled by the switch panel on the right-hand side of the body. Two press buttons on the left-hand side of the push-button box start and stop the main motor, and two buttons on the right control the suds pump motor. The spindle can be started, stopped, and reversed by the adjacent ball-ended lever.

Power is transmitted direct from the motor to the multi-splined spindle through heat-treated spur gears having ground teeth and running in oil. The arrangement reduces the number of gears



MOTOR-DRIVEN VERTICAL MILLING MACHINE

in the train, and they have stiff transmission shafts mounted on ball and roller bearings, thus ensuring efficiency. As the motor is controlled electrically from the front of the machine, no clutches are necessary in the transmission. The table is driven by a rotating feed nut engaging a non-rotating feed screw of large diameter and coarse pitch. The screw is not splined and is always in tension, while the phosphor-bronze nut is of great length and is adjustable for wear. The thrust of the cut is taken on ball thrust bearings.

Twenty-four rates of reversible automatic feed from ½in. to 60in. per minute are provided to the longitudinal and cross movements of the table. The feeds and quick power longitudinal traverse of 200in. per minute are driven by an independent 2 H.P. horizontal flanged motor. The electrical gear is so arranged that any fault or overload in the main motor automatically trips the feed motor.

There are three ranges of feed—coarse, medium, and fine—the range required being selected by a lever on the right of the machine. When changing the feed range, a foot pedal at the front of the machine is depressed and released again after the change. The feed required is quickly obtained by rotating the pilot handle at the front of the apron until the appropriate feed is opposite a pointer. Two levers are provided at the front of the machine to engage the longitudinal and cross feeds respectively. The feeds are the same in both directions of the table travel, which is a great advantage when milling such work as triangular ports in locomotive piston valves. A lever at the front of the apron is used for reversing the direction of either feed.

Hand adjustment of the table in both directions is effected by hand wheels conveniently placed at the front of the apron, where all the other controls are grouped. This arrangement is particularly advantageous for die sinking and similar work, as it is possible for the operator to control the table in both directions without moving from his position.

The quick power traverse to the longitudinal motion of the table is entirely independent of the feed motion, and may therefore be engaged without setting any other levers, immediately the feed has been automatically tripped. The control lever is always moved in the direction in which the table is required to travel and may be operated with the spindle stationary or revolving. When the control lever for the quick power traverse is put into the vertical position the table stops without the feed levers being operated, which operation is necessary where a common shaft is used for both feed and quick power traverse. Rapid power traverse for the transverse motions of the table is obtained by using the coarsest feed of 60in. per minute. Both the feed and quick power traverse are provided with automatic and dead stops.

Lubrication of the machine has received special attention; all the important mechanisms are lubricated by oil baths, feeding cups being provided in convenient positions for replenishing the oil. If the machine is intended for machining steel, a motor-driven pump and fittings can be supplied. The pump is of the centrifugal electrically driven type, controlled by a direct-on contactor with start and stop push-buttons grouped with the main motor push-buttons on the left-hand side of the machine.

A 24in. circular table can be supplied, if desired. This table is driven by a self-contained motor and feed box giving six rates of reversible automatic feed. Hand feed is also provided. The electric controls are so arranged that the table driving motor stops whenever the main motor and cutter spindle is stopped.

The principal dimensions are:

	Inches.
Automatic longitudinal feed	48
Automatic transverse feed	16
Maximum distance from surface of table to spindle	23
Minimum distance from surface of table to spindle	7
Vertical adjustment of spindle head	16
Distance centre of spindle to column face	18
Working surface of table...	72×17

VITREOSIL DISCS.—Porous discs made of Vitreosil, pure fused silica, are now being made in this country by the Thermal Syndicate, Ltd., of Wallsend-on-Tyne. Formerly these discs were produced only in Germany. They are used for filtering liquids and gases and there are tubes with such discs for distributing gases in liquids. The discs can be made up in various sizes and grades of porosity and can be used up to 900 deg. Cent.

The "Juneero" Construction Equipment

ON the market at the present moment there are several forms of "home construction" equipment designed primarily to amuse and instruct young people of a mechanical turn of mind. For the most part they make us regret that we ourselves have lost our first youth. Nevertheless, as grown-up engineers we may perhaps venture on a criticism which the young constructor—or, at least, those responsible for placing the equipment in his hands—may be advised to consider with due attention. The different equipments which we have so far seen provide, for the most part, ready-made items and leave the constructor with little more to do than to assemble them. It is true that scope for ingenuity still remains in arranging the parts to fulfil some function or reproduce some design. Still, we feel assured that if the making of the parts themselves as well as their assembly could be left to the young constructor, he would receive a double benefit from his hobby. Further, there can be little doubt that to the more fastidious-minded the existence in their finished work of holes and other features which are not essential to it, and which are present solely because the parts are intended to be reused for many purposes, does detract somewhat from the satisfaction to be derived from contemplating the completed job. Our readers will doubtlessly be aware, too, that considerable use is now being made of home construction sets for a number of serious purposes, such as trying out suggested mechanisms or making working models for demonstration at lectures. Here, also, the fact that the constructor is confined to the use of standardised parts which have to serve a variety of purposes may well hamper the full and artistic realisation of a particular scheme.

A new home construction equipment known as "Juneero" has been submitted to us for our inspection by Juneero, Ltd., of White Street, London, E.C.2. It is clearly not open to the criticism which we have expressed above, for it supplies only the raw material from which to make the parts and leaves the constructor to fabricate them with the aid principally of an ingenious little lever-operated hand press. The raw material is in the form of steel strips and rods, circular metal discs of various sizes, plain and corrugated sheet metal, angle iron, glass substitute, &c. The hand press provides a pair of jaws for bending the strip at right angles, a punch for piercing holes in the strip or sheets, shears for cutting the strip to length, and shears for cutting off the rods. It is equipped with a gauge bar to facilitate cutting off a number of strip or rod pieces to the same length, with a jig for bending the rods and with a vice for holding the rods while their ends are being screwed with the aid of a die which is included in the equipment. Nuts, small bolts, springs, and gear wheels can also be obtained, although these details must not be regarded as raw material but as finished parts.

Other equipment included in the set sent to us for examination comprises a screwdriver and spanners, metal-cutting hand shears, a pocket knife, and a "scroll tool" by means of which the strip and rod may be bent to a circular form of various radii.

It will, we think, be readily understood that this new home construction equipment offers opportunities for producing objects or fitments which are intended to last and to serve some useful purpose, as well as affording amusement to the younger generation. There are many purposes to which it might be put in the home for producing small details or effecting repairs. It would not, we think, be considered purely a toy even in a laboratory where extemporised apparatus has frequently to be devised. We gather that it is the intention of the makers to add further tools and material to the list already available. We trust that in doing so they will bear in mind the desirability, from the point of view of their younger followers, of leaving to them as much as possible of the fabrication of the parts they wish to use, and, further, from the point of view of those who are not so young, that they will keep before them the use of the equipment otherwise than as a toy.

THE BRITISH RHEOLOGISTS' CLUB.—The inaugural meeting of the British Rheologists' Club (which concerns itself with the flow and deformation properties of materials), was held on November 16th, at the University of Reading. The meeting was well attended, members coming from all parts of the country. Professor J. A. Crowther, Professor of Physics in the University, presided. The morning session was devoted to a discussion of "Rheology in Industry," the opening speakers being Mr. J. Pryce Jones and Mr. F. D. Farrow. After lunch the meeting adjourned to the National Institute for Research in Dairying at Shinfield, where, by kind permission of the Director, Professor H. D. Kay, the rheological apparatus of the Institute was shown. This opportunity for exchange of views and for gaining a knowledge of new instruments was welcomed by all who attended the meeting. It was generally agreed that they would return to their various problems in rheology, many of which are now of national importance, with fresh ideas and new weapons of attack.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Imports of Iron and Steel

The Board of Trade Returns in their war-time form give the total imports during October as valued at £85,095,565, an increase of £23,224,165 over the figure for October, 1939, but only £6,016,662 above that for October, 1938. For the ten months ended October 31st the imports were valued at £953,724,966, or £236,485,541 greater than in the same period of 1939 and £184,182,062 above the value of the imports in 1938. Imports of non-metalliferous mining and quarry products and the like were valued at £509,587, which was an increase of £128,244 over the corresponding month of 1939. Iron ore and scrap was imported to the value of £1,577,496, a rise of £755,016 when compared with the value of the imports in October last year. Non-metalliferous ores and scrap were imported to the value of £1,722,267, an increase of £360,894 when compared with the value of the imports in October, 1939. The imports of iron and steel and manufactures thereof reached a total value of £5,857,443, which was £4,775,726 more than in October, 1939. The value of non-ferrous metals and manufactures thereof imported last October reached £6,151,603, or £3,514,286 more than the value of the imports in the corresponding month of last year. The imports of cutlery, hardware, implements and instruments were valued at £235,719, which was £55,888 less than the value of the imports of similar material in October, 1939. Electrical goods and apparatus were imported to the value of £139,639, or £62,707 below the value in October, 1939. The value of imports of machinery in October at £3,446,813 was £1,326,053 greater than in October, 1939. Vehicles, including locomotives, ships, and aircraft, were imported during October to the value of £3,050,773, or £2,836,117 above the value for the corresponding month of 1939.

Our Iron and Steel Exports

The total exports of all classes of goods in October were valued at £23,390,911, which was £1,231,929 less than in October last year and £19,169,085 lower than in October, 1938. For the ten months ended October 31st the value of our exports reached £366,995,190, which is £5,671,020 more than the value of the exports for the first ten months of 1939 and £22,170,216 below those for the same period of 1938. The exports of coal in October last were valued at £1,338,751, or £1,895,761 less than in October, 1939. Non-metalliferous mining and quarry products and the like were exported to the value of £42,157, which was £67,983 less than the value of October, 1938. Iron ore and scrap exports, as might have been expected, were poor, amounting in value to only £186, a drop of £904 compared with October last year. Non-metalliferous ores and scrap were exported to the value of £1864, which was £18,140 below the value of similar exports in October last year. The value of exports of coke and manufactured fuel in October totalled £40,022, which was £288,857 below the October, 1939, value. Iron and steel and manufactures thereof were exported in October to the value of £1,748,201, which showed a reduction of £153,598 on the value of similar exports in October, 1939. The exports of non-ferrous metals and manufactures thereof reached a total of £690,365, or £272,399 lower than in October, 1939. Cutlery, hardware, implements, and instruments were exported to the value of £560,836, a rise of £125,850 when compared with the exports in October last year. Electrical goods and apparatus were exported to the value of £706,420, an increase on the exports of the corresponding month of last year of £196,382. The value of machinery exports reached £2,122,577, which was £64,772 more than the value of similar exports in October, 1939. Vehicles exported, including locomotives, ships, and aircraft, reached a value of £2,406,268, which was a rise when compared with October, 1939, of £1,043,428.

The Pig Iron Market

The volume of business in the pig iron market shows signs of becoming more restricted, but this is probably because so many consumers have already covered their requirements well into next year. It is reported that there will probably be a considerable tonnage of uncompleted contracts to be carried forward into the next allocation period. Consumers are said to be well sold until the end of the year, and in many cases are behind in deliveries and are making strenuous efforts to overtake their accumulated orders. The position of the pig iron trade varies little in the different districts in Great Britain. On the North-East Coast the buying shows a tendency to shrink with the approach of the end of the year, since most consumers have bought to the full extent permitted by the Control. For the time being consumers are more concerned with securing deliveries against their contracts than in making fresh purchases. The foundry trades generally are more active, probably, than at any time this year, and this applies particularly to the light castings foundries which have experienced a slight improvement in the demand for domestic castings, whilst at the same time a number have been given Government work. There has been a rather active demand for foundry iron in the Midlands, and there does not seem to be any surplus of low phosphoric iron when consumers' demands have been met. The Midland light castings foundry makers are also taking larger supplies of this class of iron, but production is on a good scale, so that there is no sign of any tightness in the market. Imports of high phosphoric iron and hematite have eased the situation in that department, and although considerable quantities are required from the Midlands by the engineering foundries, supplies are adequate to meet all requirements. Some irregularity exists in the consuming trades in Lancashire. The jobbing and engineering foundries are fully employed, but here and there some falling-off in the rate of operations is reported, and although there has been some improvement in the light castings industry in this district, the works are by no means busy. The Scottish production of pig iron is heavy, and all classes of consumers are receiving full supplies. There is still some inactivity in the Scottish light castings trade, but the situation shows an improvement which looks like continuing.

Copper and Tin

The concentration of industry upon the production of armaments and munitions results in the absorption of a great proportion of the available copper, and naturally the Non-Ferrous Metal Control devotes most of its energies to supplying firms engaged in the war effort. Whilst there seems to be plenty of copper available for the war industries, the demands for ordinary civilian purposes have to be relegated to the background. In the United States the copper position has not changed much. The domestic price appears to be firmly pegged at 12c. d/d, whilst for export the quotation has strengthened slightly from 10c. to 10·50c. Producers in the United States are apparently rationing their customers, and whilst it is stated that all consumers will get the copper they require in time, any attempt to cover far forward is discouraged, and this attitude seems to have been accepted by users as perfectly reasonable in the circumstances. Export business has been poor, but there has been some inquiry from Japan, and that country apparently is still unable to obtain all the metal she would like. Russia also has been in the market and India has bought spasmodically. It is perhaps owing to the difficulty of getting copper that there has been a stronger demand for manufactured copper and brass products for export. India is understood to have bought copper sheets with some freedom. . . . Dull conditions have prevailed in the tin market and prices have moved within a narrow margin. Export licences do not seem to have been granted with so much freedom lately, with the result that the contango has widened to about 45s. This is because nearby tin is not in demand for export. The stocks in this country are considered adequate, although they declined somewhat in October. In the East sales have been considerable, but the greater part of these have been for shipment direct to the United States. At the moment there does not seem to be any particular incentive to buy or sell tin and it is not expected that there will be any important decline in price whilst the American Government maintains its buying figure at 50c.

Lead and Spelter

The lead position in Great Britain is quite comfortable, and whilst large quantities are going to the munition makers there seems to be more lead available for ordinary commercial purposes than is the case with other non-ferrous metals. This is partly because of the comparatively negligible demands from the building trade, which in peace time absorbs a good proportion of the lead supplies of this country. In the United States the price has been successively reduced from 5·80c. to 5·65c. to 5·50c., New York. The decline is due to the quiet conditions which have developed in the American lead trade, but it is anticipated that this is only temporary, since lead will be used extensively as a result of the American armament drive. Little export business is passing in lead, since so many countries which are large consumers in normal times are now under German domination. India is apparently being supplied with lead from Burma, whilst South America is getting Mexican lead. . . . There has been no relaxation in the tight conditions ruling in the world spelter markets. This is principally due to the lack of available refining capacity. By overrunning France, Belgium and Poland Germany became possessed of a large amount of plant, but these countries were to a great extent dependent upon imported ores, which, of course, are now unobtainable owing to the British blockade. Some of these ores are no doubt going to the United States, but whilst America has a big refining capacity it is not large enough to absorb the supplies which went to European countries in pre-war days. American industrialists are naturally reluctant to expand their smelting capacity, since when the war ends the plants in Belgium, France and Poland will resume operations, with the result that there would probably be an over-production. In fact, at the moment it would appear that there is a glut of concentrates in the world and a dearth of available refining capacity. There is practically no export business in spelter. In the United States the position remains tight, although the price is firm at 7·25c., East St. Louis. The stocks there are reported to be low.

Non-Ferrous Metal Prices

The London Metal Exchange statement for November shows little change in the average prices for tin during that month. The cash quotation shows a rise of 4s. 6d. over the average for October whilst for three months' metal there was a drop of 5s. 2d. The average for settlement was 3s. 8d. higher in November than in the previous month. The statement, which includes the official maximum prices for copper, lead and spelter, is as follows :

Standard tin	Cash (mean)	£258	7	6
	Three Months (mean) ...	£260	5	1½
	Settlement	£258	6	5½

The following prices for copper, lead, and spelter are the maximum prices fixed by the Controller of Non-Ferrous Metals :—

	£	s.	d.		
Standard copper					
Electrolytic copper ...	62	0	0	delivered buyers' premises	
Electrolytic wire bars ...	62	0	0	,,	,, ,,
Best selected copper ...	60	10	0	,,	,, ,,
Lead, good soft pig (foreign) ...	25	0	0	,,	,, ,, (duty paid)
Spelter, G.O.B. (foreign)	25	15	0	delivered buyers' premises	(duty paid)

Notes and Memoranda

Rail and Road

RAILWAY "WASTE."—During the past three months the L.M.S. Railway has collected 4045 tons of waste of all descriptions. Included in this total are scrap metal, 2193 tons; waste paper, 1287 tons; rope, 193 tons; timber, 216 tons; bricks, 45 tons; cotton and wool pickings, 2½ tons; and 65,706 bottles.

GERMAN METAL SHORTAGE.—Owing to the shortage of lead, nickel, cadmium and mercury in Germany the High Command of the Reichswehr has offered a prize of 10,000 reichsmarks for the successful design of a leadless electric storage battery to meet specific mechanical and electrical requirements. It is hoped that such a battery may be used in motor vehicles to cut out the use of liquid fuels for propulsion.

A GREAT SCHEME.—The Canadian approach to the Rainbow bridge now being constructed across the Niagara River to link the twin cities of Niagara Falls is to be "the finest in the world." It is expected that when the scheme is finished about 50 per cent. of the travellers into Canada will enter at this point to travel over the Queen Elizabeth Way, and the authorities are determined to make it worthy of the name.

SWEDISH ELECTRIFICATION.—Last year the Swedish Riksdag granted a further 8,000,000 kr. for the completion of the then existing programme for the electrification of certain lines on the State Railways. Difficulties of obtaining with certainty and economy supplies of foreign fuel has caused the allocation to be increased to 16,000,000 kr., so that further lines may be converted and greater use made of the country's hydraulic power resources.

A CHAIN ROPE RAILWAY OPENED IN GERMANY.—An underground chain rope railway, reported to be the first of its kind, has recently been inaugurated by the Mansfeldsche Kupferschieferbergbau A.G., Mansfeld, the only copper mine in Germany. The line, which is nearly 3 kiloms. long, is electrically driven and each of the small locomotives operating draws thirty-five wagons weighing 550 kilos. each, or fifteen passenger cars with eight workers each. The construction cost of the railway is stated to have been approximately Rm. 1,000,000.

A 66IN. GAUGE.—How the gauge of British-owned railways in Argentina was fixed at 5ft. 6in. was the subject of a note in a recent issue of the *Railway Age*. It appears that the first locomotive to operate in Argentina—on the Buenos Aires Western—was originally built in Leeds in 1854 for use in India, where the 5ft. 6in. gauge was standard as "broad gauge." The locomotive never ran in England, but was instead used in the Crimea in military service and sold shortly after the Crimean war to contractors in Argentina, where it hauled the first train on the opening day of the Buenos Aires Western on August 29th, 1857.

WOMEN ENGINE DRIVERS.—More than half a million women are now employed on the railways of the U.S.S.R., and some of them perform such duties as those of engine drivers and stationmasters, formerly considered the sole province of men. To-day there are fifty-six women engine drivers and 2900 assistant engine drivers. In addition, many women are employed as motormen of electric trains. The Soviet railways have an extensive system of training courses (attended by both men and women) for those who enter the railway service. Last year the number of persons attending these courses was 109,200.

Air and Water

CONCRETE FLOATING DOCK.—It is reported that a ferro-concrete floating dock of 4000 tons capacity, intended for service at Murmansk, is under construction at Leningrad.

A BIG HANGAR.—The Dorval airport for Trans-Canada Air Lines, near Montreal, is to have the largest aeroplane hangar in the Dominion. The work has already been begun. The building will measure 200ft. by 150ft. and be 27ft. high. It will have a reinforced concrete foundation with a steel fabric structure and metal siding. An annexe at the rear will be 200ft. by 50ft. and will serve as a stores depot and service building.

CANAL TRAFFIC IN BELGIUM.—An increase in the mileage of inland canals open to traffic is reported from Belgium. Under orders from the German authorities, an inland shipping organisation of all owners operating barges of 50 tons and over has been established, with headquarters in Antwerp. Management and operation of shipping is entrusted to a Board of Inland Shipping appointed by the Belgian Ministry of Public Works.

GLASGOW HARBOUR EQUIPMENT.—New equipment for Glasgow harbour, costing more than £100,000, has been sanctioned by the Clyde Navigation Trust. Among the items specified are six 8-ton electric level luffing cranes, four 3-ton electric travelling portal level luffing cranes, and the conversion to level luffing type of two 8-ton and eleven 4-ton existing fixed jib cranes. New electrical switchgear, distribution cables and other equipment will cost nearly £3500, and mercury vapour rectifier plant is to be installed.

HYDRO-ELECTRIC PLANT IN PHILIPPINES.—The Philippine Government has launched an ambitious scheme to install a hydro-electric plant. The project consists of an artificial reservoir and power plant to be built on the Caliraya River, Lumbang, Laguna, and transmission lines to Manila. Construction is under the direction of the National Power Corporation, which in turn is governed by the National Power Board appointed by the President. The Caliraya dam, 116 kiloms. from Manila by road, is to be completed up to an elevation of 284 m. by December 31st, 1941, and completed (to elevation 292 m.) by June 30th, 1942. The reservoir will cover an area of 11,613,619 square metres and will have a usable capacity of 78,000,000 cubic metres. After providing for infiltration, evaporation and other losses, the reservoir should have enough water stored during rainy seasons to last through the dry seasons of the driest years.

POWER AT PITTSBURG.—Greater Pittsburg, within the last two or three years, has installed plant up to 170,000 kW generating capacity, and an additional 120,000 kW is under construction and will be available next year. Ample supply of electricity during major floods has been assured, as those responsible have provided bulkheads and other protective measures in generating stations, major sub-stations and elsewhere for a flood stage 3ft. to 4ft. greater than the March, 1936, flood. This is equivalent to 25 to 30 per cent. more flood water.

AMERICAN SHIPBUILDING.—The expansion of the American Navy is giving the Pacific Coast shipyards much new work. Though no battleships will be built on this coast, the Bethlehem Steel Company's San Francisco Union plant, which has already built two destroyers, has been assigned four cruisers and eighteen destroyers of the "two-ocean" navy programme. Puget Sound gets twenty destroyers assigned to the Seattle-Tacoma Shipbuilding Company, and the Los Angeles area will have six destroyers at Bethlehem's San Pedro plant, and a repair ship at Los Angeles Shipbuilding and Dry Dock Company.

LAUNCH OF THE "ROBIN LOCKSLEY."—The first of six ships building for the Seas Shipping Company, operators of the Robin Line, has been launched at the Sparrows Point Yard of the Bethlehem Steel Company. She is the "Robin Locksley," of about 7400 tons gross. Her keel was laid on February 23rd and she will enter the service between New York and Baltimore and South and East African ports towards the end of January. The "Robin Locksley" is 450ft. in length between perpendiculars, 480ft. overall, 66ft. in breadth and 43ft. in depth to shelter deck. She will have a displacement of 15,075 tons, and a carrying capacity of about 9700 tons deadweight.

Miscellanea

MANGANESE PRODUCTION IN THE URALS.—A new Soviet manganese-producing centre is being established in the North Urals. The district contains one of the largest manganese ore deposits in the Soviet Union. The preliminary survey of the route for a new railway running from Ivdel to the manganese deposits has already been completed.

AUTOMATIC FEED FOR LATHES.—A Soviet engineer, A. B. Diskin, has designed an apparatus, known as a "mechanical hand," which renders the machining of cylindrical parts automatic. When attached to a lathe, Diskin's apparatus feeds the parts automatically into the chuck and, after the operation is completed, passes on the part for the next process. One operator is able to tend twelve or more machine tools fitted with Diskin's device.

ROENTGEN MONOCLE.—Enabling surgeons to operate under direct X-rays, an apparatus, named by its inventor a "Roentgen monocle," has been designed by a Russian physician, A. A. Dlugokansky, serving in the Soviet Navy. The invention consists of an aluminium mask with a lead lining, a tube for one eye and a screen. The mask protects the surgeon against the action of the X-rays, while the tube and screen permit him to see clearly the tissue he is operating on, the foreign body and the surgical instrument.

TIN SMELTING IN U.S.A.—The United States Government has decided to erect a smelting plant for Bolivian tin concentrates, hitherto smelted in the United Kingdom. The refinery will be set up under the auspices of the Reconstruction Finance Corporation, with an annual smelting capacity of 18,000 tons of metallic tin. Construction will require about twelve months. It is probable that the plant will operate only during the war, as normally refining costs in Britain are lower.

WOOD CHARCOAL.—Charcoal burning—one of Britain's oldest industries—is the subject of a recent report of the Ministry of Supply. Before the war Britain produced less than half of the wood charcoal consumed, and the craft of charcoal burning, entailing a hard and solitary life, survived only in a few places. To-day, production has been more than doubled by the use of a new kind of steel kiln which can be moved from place to place, wherever suitable wood is available, and can be worked by unskilled labour under skilled supervision. In this way the need for importing from remote sources, including the Gold Coast, the Philippines, and India, has been materially reduced.

ALUMINIUM IN THE FAR EAST.—To foster the development of the domestic aluminium industry, the Japanese Government proposes to provide bounties to manufacturers of high-grade alumina during the five years 1940–44. To qualify for the subsidy this year, the alumina produced must contain a minimum of 97 per cent. aluminium oxide, less than 0·15 per cent. silica, less than 0·1 per cent. ferric oxide, and less than 0·7 per cent. sodium oxide. To secure the bounty in 1944, the Al_2O_3 content of the alumina must be at least 98 per cent. Only licensed aluminium manufacturers and chemical firms are entitled to the subsidy. It is significant that the regulations do not specify that the aluminium must be prepared from ores other than commercial bauxite.

LIQUID OXYGEN EXPLOSIVES.—In the first World War, due to the blockade that shut off importation of nitrates, Germany developed liquid oxygen explosives for use in demolitions behind the lines. Explosives of this type consist essentially of a carbonaceous absorbent saturated with liquid oxygen. The resulting cartridges may be detonated to give a powerful explosive. Recently, considerable publicity has been given to the claim that liquid oxygen explosives may be used in aeroplane bombs. A serious disadvantage of such explosives, however, is the ease with which they may be ignited by a chance spark to give violent detonation. In America the Bureau of Mines, as the result of a research study conducted in co-operation with other interests, has developed a successful procedure for fireproofing the cartridges and thus eliminating this menace without affecting the useful explosive qualities.

AMERICAN NITROGEN PLANT.—The United States War Department is to make a contract with the Tennessee Valley Authority for the construction of a modern nitrogen fixation plant near Muscle Shoals, Alabama. The plant will be owned by the War Department, operated by the T.V.A. as agent, and will have a daily capacity of 150 tons of ammonium nitrate.

CANADIAN ACTIVITY.—The Hon. C. D. Howe, Canadian Minister of Munitions, has announced that an immediate start will be made on the construction of a major plant in the Canadian war industries development programme "somewhere in Southern Ontario," at a cost of some 5,500,000 dollars. The plant will increase the Canadian output of special alloy steels by thousands of tons monthly, and will be in operation in 1941, well before the present armament programme reaches its peak production.

HONG KONG POWER STATION.—Another stage in the development of the China Light and Power Company, Ltd., was recently marked by the inaugural ceremony which put into formal commission the company's new power station at Hok Un, Kowloon, Hong Kong. The ceremony, held in the huge boiler-house of the new station, was attended by about 1500 people. The opening was performed by the Governor, Sir Geoffry Northcote, supported by Mr. L. Kadoorie, chairman of the board of directors, who gave a notable account of the development of the company and its new station.

Personal and Business

MEK-ELEK ENGINEERING, Ltd., informs us that in future all communications should be sent to 17, Western Road, Mitcham, Surrey.

J. SAMUEL WHITE AND CO., Ltd., Cowes, have announced the retirement through ill-health of Mr. A. T. Wall, who has been managing director since 1933.

MR. H. ELLIOTT, of Pickfords, Ltd., has been appointed by the Ministry of Supply as Controller of Road Transport in the Department of the Controller-General of Transportation.

MR. J. M. GREATHEAD, Chief Civil Engineer, South African Railways and Harbours, has been appointed Assistant General Manager (Technical) in place of Mr. W. A. Day, who has retired.

MESSRS. MERZ AND MCLELLAN announce that they are taking into partnership Mr. Charles Lord Blackburn and Mr. Thomas Graeme Nelson Haldane, who have been members of their staff for a number of years.

MR. C. W. SULLY has retired from the directorship of the Electric Lamp Manufacturers' Association, a position which he has held since 1923. Prior to joining the Association Mr. Sully served with Crompton and Co., Ltd., the New York Edison Company, and at home and overseas with Siemens Brothers and Co.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Bradford Engineering Society

Monday, Dec. 9th.—Technical College, Bradford. "Impact and Notched Bar Testing," C. N. Waterhouse. 7.15 p.m.

Chemical Engineering Group

Tuesday, Dec. 10th.—Burlington House, Piccadilly, W.1. Discussion on "The Salvage of Waste Materials in the Chemical Industry," to be opened by Dr. A. B. Manning. 2.30 p.m.

Illuminating Engineering Society

Tuesday, Dec. 10th.—E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, W.C.2. Demonstrations on "Effects of Contrast in Illuminating Engineering." 2.30 p.m.

Institute of Welding

Wednesday, Dec. 11th.—SCOTTISH BRANCH: 39, Elmbank Crescent, Glasgow. "Fabricated Components *v.* Castings." 7 p.m.

Institution of Locomotive Engineers

Tuesday, Dec. 10th.—Royal Empire Society, Northumberland Avenue, W.C.2. Luncheon, 12 for 12.45 p.m.; general meeting, 2.30 p.m.

Institution of Mechanical Engineers

Friday, Dec. 13th.—STEAM GROUP: Storey's Gate, Westminster, S.W.1. "The Physical Aspect of Steam Generation at High Pressures and the Problem of Steam Contamination," R. F. Davis. 2 p.m.

Junior Institution of Engineers

Saturday, Dec. 14th.—39, Victoria Street, S.W.1. Presidential address, Viscount Falmouth. 2.30 p.m.

Manchester Association of Engineers

Saturday, Dec. 14th.—Engineers' Club, Albert Square, Manchester. "Some Experiences in Organising the Design and Manufacture of Small Engineering Apparatus," G. A. Cheetham. 2.30 p.m.

Royal Society of Arts

Wednesday, Dec. 11th.—John Adam Street, Adelphi, W.C.2. "Road Transport," J. S. Nicholl. 1.45 p.m.

Friday, Dec. 13th.—John Adam Street, Adelphi, W.C.2. "Industrial Development in the Indian Provinces," S. Lall. 1.45 p.m.

Society of Engineers

Monday, Dec. 9th.—17, Victoria Street, S.W.1. Annual general meeting. 1 p.m.